Devils Lake
Infrastructure Protection Study

Summaries of Previous Investigations of Devils Lake Features

(Sections 2.1 through 2.25)

Prepared for

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St. Paul District

by

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2.1 Summary of Economic Analysis Investigation for Feature 1: Churchs Ferry

2.1.0 Flood Protection Strategy

The Economic Analysis of Devils Lake Alternatives indicated that the flood protection strategy with the largest net benefits for Churchs Ferry was relocation of structures.

2.1.1 General Information

Feature Type: Community

Location: Churchs Ferry is located approximately 23 miles northwest of Devils Lake, ND on US Highway 2. The accompanying Figure 2.1-1 shows the feature's location and approximate extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: Churchs Ferry is a community of approximately 77 people (based on 2000 census). Since this census was completed, many of the residences have been relocated.

Significance: The value of all the communities in this study is high because of the density of infrastructure in this primarily rural section of North Dakota. Churchs Ferry has been affected by the rising lake level over the last few years, and more structures could be affected by rising lake levels.

Damages: The flooding of Churchs Ferry would result in the following damages:

- loss of 3 homes
- loss of a grain elevator
- loss of a church

Owner/Sponsor: The community of Churchs Ferry is responsible for managing and maintaining Churchs Ferry.

Lead Federal Agency: Corps would take the lead for Churchs Ferry for any flood protection work that may take place. Federal Emergency Management Agency (FEMA) would coordinate relocation of structures.

2.1.2 Feature Protection

History of Flood Protection: In the past, flood protection for Churchs Ferry has consisted of constructing a levee to 1451.5 and conducting a buyout program which was implemented in 2000. Only 3 residents decided to forego the buyout offer, all of which are located between 1456 and

1464. The existing sewage lagoons are serving only the 3 remaining residences. The cost to protect the lagoons is $150,000, which is greater than the value of these 3 homes. Therefore, it was assumed that if the lake rose to the level of the lagoons, they would be abandoned and damages would be ignored. It was assumed that the existing levee would not be raised because the cost of raising it would greatly exceed the value of the few structures that it would protect.

General Protection Strategy: The Economic Analysis identified and evaluated the following approach for protecting Churchs Ferry:

- relocation of 3 homes, a grain elevator, and a church

Protection Strategy by Lake Level: The Economic Analysis of Devils Lake considered various protection strategies, with flood-protection decisions being made at various lake levels as Devils Lake continued to rise. Figure 2.1-2 shows the decision tree for Churchs Ferry. As shown on Figure 2.1-2, the stepwise approach to flood protection for Churchs Ferry consisted of the following:

1. At lake elevation 1447, the structures below 1456 would be relocated.
2. At lake elevation 1455, relocation would occur for structures between elevations 1456 and 1464.

The maximum protection strategy that was analyzed at the first action level was relocating all structures below elevation 1464. (Note that for the Economic Analysis of Devils Lake, the decision regarding relocation of structures is made at a time when the lake is one foot below the low structure elevation.)

Interdependencies: The protection of Churchs Ferry is related to the protection of the highways that serve it. These highways include:

- Feature 13: US Highway 2
- Feature 16: US Highway 281 (South of US Highway 2)
- Feature 17: US Highway 281 (North of US Highway 2)

These highways are critical for Churchs Ferry in that they provide the main transportation routes in and out of the community.

Table 2.0-1, mentioned earlier in this report, provides a summary of the interdependencies among the features.

2.1.3 Feature Economics

Damages: For Churchs Ferry the damages resulting from flooding were estimated up to the maximum lake level (1463). The damage computations for Churchs Ferry are summarized in the accompanying Table 2.1-1.

The first portion of the table shows the damages that are associated with each action level (1447 and 1455), each representing damages within a range of lake levels. The second portion of the table is a breakdown of the damages associated with each action level. Damages listed include houses, a grain elevator, and a church.

Unit costs for all the damage computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for Churchs Ferry are listed in the Churchs Ferry Economic Analysis Assumptions listing, attached to this Section 2.1.

Costs: The costs of providing flood protection for Churchs Ferry are detailed in the accompanying Table 2.1-2. Unit costs, data sources, and relevant assumptions are listed.

The first portion of the table shows the cost of relocations that are associated with each action level (1447 and 1455). The second portion of the table is a breakdown of the relocations associated with each action level and their costs.

Unit costs for all the cost computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for Churchs Ferry are listed in the Churchs Ferry Economic Analysis Assumptions listing, attached to this Section 2.1.

2.1.4 Results of Economic Analysis

The results of the Economic Analysis for Churchs Ferry are listed in Table 2.1-3.

Stochastic Analysis Results: The stochastic analysis indicated that the strategy with the largest net benefits for Churchs Ferry was incremental relocation of structures. This strategy is highlighted on the decision tree (Figure 2.1-2). The annual net benefits for this strategy were less than zero (-$700). The negative net benefits indicate that this strategy is not economically justified. The BCR for this strategy was approximately one (1.00). The stochastic results are averages over 10,000 traces.

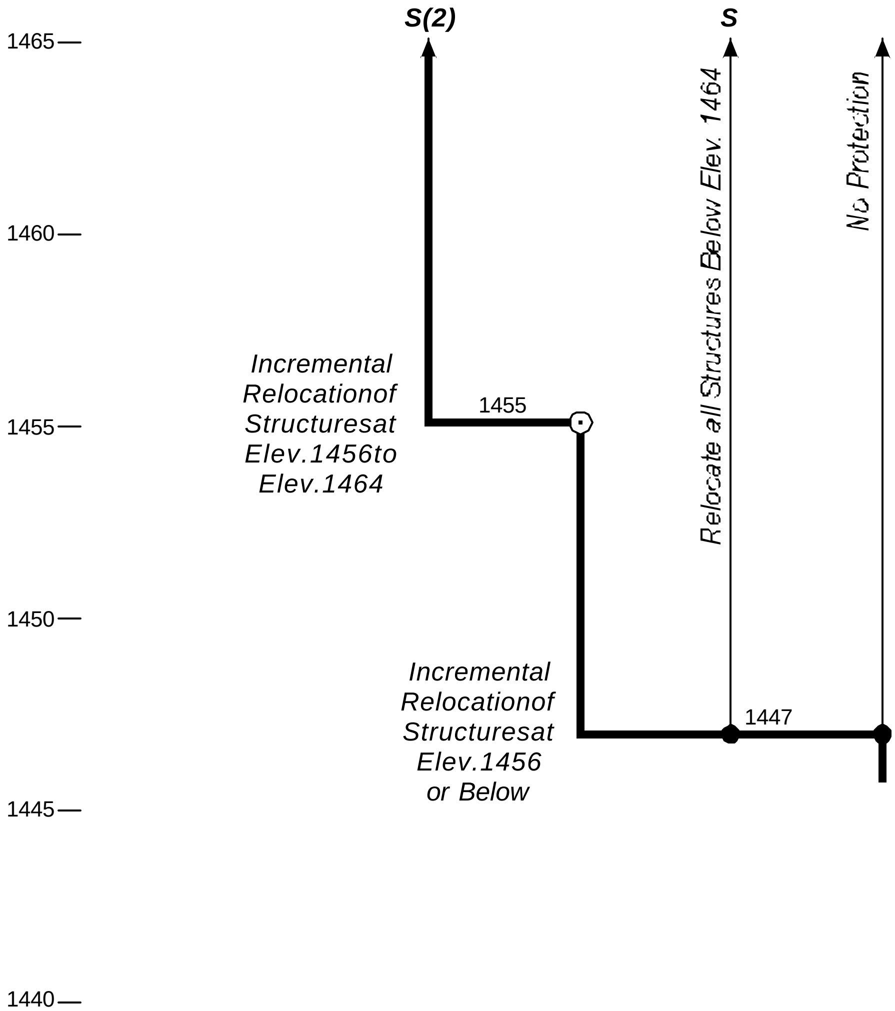
Results for Specific Scenarios: In the economic analysis, flood-protection strategies were also analyzed for three specific climate futures. For Churchs Ferry, the flood protection strategy and the economic indices for each of the three climate futures are as follows:

- Wet Future – For the wet future, the strategy with the largest net benefits was shown to be two incremental relocations of structures. For this strategy, the net benefits were -$5,300 and the BCR was 0.98, indicating that this strategy was not economically justified.
- First Moderate Future – For the first moderate future, the strategy with the largest net benefits was shown to be three incremental relocations of structures. For this strategy, the net benefits were -$400, and the BCR was 0.91, indicating that this strategy was not economically justified.
- Second Moderate Future – For the second moderate future, the strategy with the largest net benefits was shown to be three incremental relocations of structures. For this strategy, the net benefits were -$400, and the BCR was 0.91, indicating that this strategy was not economically justified.

Figure 2.1-1

LOCATION MAP
FEATURE 1: CHURCHS FERRY
Devils Lake Infrastructure
Protection Study

Data: 1997 USGS Digital Ortho Quad



Note: NoStructuresareLocatedBetween1451and1456

P:3436\2010\DECISION TREES\2012FIGURES\FIGURE2_01.CDR RLG 01-02-03

(solid line)	FloodProtectionStrategy
●	Decisionrequiredatthispoint
⊙	Triggerpointforaction,nodecisionneeded
L(1)	Incrementalleveeraise(numberoftimes)
L	LeveeraisetoElev.1468
S(1)	Structurerelocation(numberoftimes)
S	RelocateallstructuresbelowElev.1464

Figure2.1-2

DECISION TREE
FEATURE 1:CHURCHSFERRY
DevilsLakeInfrastructure ProtectionStudy

Table 2.1-1

Flood Damages
Feature 1: Churchs Ferry
Devils Lake Infrastructure Protection Study

DAMAGES

Action Level	Lake Elevation	Structure Elevation Range	Structures and Infrastructure
	(MSL)	(MSL)	(THOUSANDS)
AL1	1447	Below 1456	$5,314
AL2	1455	1456 - 1464	$140

DAMAGE BREAKDOWN

AL1: Lake Elevation 1447					AL2: Lake Elevation 1455				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Grain Elevator	1	EA	$5,314,000	$5,314	House	3	EA	$12,000	$36
					Church	1	EA	$104,000	$104
Total				**$5,314**	**Total**				**$140**

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.

Table 2.1-2

Flood Protection Costs
Feature 1: Churchs Ferry
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Action Level	Lake Elevation	S(2) Incremental Relocation at AL1, AL2	S Relocate All Structures at AL1
	(MSL)	(THOUSANDS)	
AL1	1447	$5,314	$5,591
AL2	1455	$277	$0

COST BREAKDOWN

		S(2)					S(2)				
		S									
		Lake Elevation 1447					Lake Elevation 1455				
Strategy		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Incremental Relocation											
	Move	Grain Elevator	1	EA	$5,314,000	$5,314	House	3	EA	######	$204
							Church	1	EA	######	$73
		Subtotal				$5,314	Subtotal				$277
		Total				**$5,314**	**Total**				**$277**

Notes:

1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. The costs for the Relocate All Structures at AL1 strategy (S) is equal to the sum of all relocations that have not been included in incremental relocations.

Table 2.1 - 3

Economic Analysis of Strategies for Churchs Ferry (Feature 1)

Strategy		Stochastic Analysis (ST) Mean Value over 10,000 Traces (Annual)								
		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit - Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I= G/D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$333,300	$333,300	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$349,800	$349,800	$0	$0	$333,300	-$16,600	0.95
S(2)	2 Incremental Relocations	$0	$0	$334,000	$334,000	$0	$0	$333,300	-$700	1.00

Strategy		Wet Future Scenario (WF) (Annual)								
		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit - Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I= G/D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$339,000	$339,000	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$351,000	$351,000	$0	$0	$339,000	-$12,000	0.97
S(2)	2 Incremental Relocations	$0	$0	$344,200	$344,200	$0	$0	$339,000	-$5,300	0.98

Strategy		Moderate Future 1 Scenario (M1) (Annual)								
		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit - Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I= G/D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$333,700	$333,700	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$351,000	$351,000	$0	$0	$333,700	-$17,400	0.95
S(2)	2 Incremental Relocations	$0	$0	$333,700	$333,700	$0	$0	$333,700	$0	1.00

Strategy		Moderate Future 2 Scenario (M2) (Annual)								
		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit - Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I= G/D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$333,700	$333,700	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$351,000	$351,000	$0	$0	$333,700	-$17,400	0.95
S(2)	2 Incremental Relocations	$0	$0	$333,700	$333,700	$0	$0	$333,700	$0	1.00

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.375% and rounded to the nearest $100.

* Total benefits are calculated as the totall damages incurred for the "No Protection strategy" minus the totall damages for the strategy implemented (F(S)).

Attachment to 2.1:
Churchs Ferry Economic Analysis Assumptions

A. General Assumptions

1. Farmland losses were not included in this feature. These losses were included in Feature 8.1: Devils Lake Rural Areas.

B. Levees

1. It was assumed that the existing levee would not be raised because the cost of raising it would greatly exceed the value of the few structures that it would protect.

2. The top of the existing levee is at 1451.5.

C. Residential And Commercial Property

1. For relocation strategies, a decision was assumed to be made when the lake is 1 foot below the level of the low structure. This was based on the existing process which is influenced by the availability of movers, the estimated lake rise each spring, and the restrictions of funding programs. Depending on the slope of the land, wave action may affect structures that are several feet above the lake's level.

2. The average relocation cost for a house is $68,000. This cost was obtained from the North Dakota-North Central Planning Council and represents the average cost to relocate a residence during the buyout program conducted in Churchs Ferry in 2000. The $68,000 includes the following costs: demolition of the existing house, purchase of an equivalent house in a nearby community, purchase of a lot, legal, appraisal, and management fees. Only 3 residents decided to forego the buyout offer, all of which are located between 1456 and 1464.

3. The cost for relocation/rebuilding of commercial and public facilities was assumed to be 100% of the value of the structure and property.

4. In 1998, the grain elevator had an insured value of $5.1 million according to Jarvis Haugeberg, grain elevator operator. This value was updated for inflation by multiplying it by the ENR Building Cost Index of 1.042. This accounts for 4.2% inflation during the period from 1998 to February 2001. The updated value is $5.3 million.

5. The 1998 average depreciated replacement value of a house was estimated to be $24,000 (*Economics Database Update for the Lands and Developments Feasibility Study, Devils Lake,* Watts & Associates, Inc., October, 1997). According to the Ramsey County Assessor, the remaining houses in Churchs Ferry are worth ½ of their 1998 value. Therefore, the average value of the 3 remaining houses in Churchs Ferry was estimated to be $12,000.

6. In 1998, the value of the church was estimated to be $100,000, including the value of the parcel. This value was updated for inflation by multiplying it by the ENR Building Cost Index of 1.042. This accounts for 4.2% inflation during the period from 1998 to February 2001. The updated value is $104,000.

7. The existing Sewage lagoons are serving only the 3 remaining residences. The cost to protect the lagoons is $150,000, which is greater than the value of these 3 homes. Therefore, it was assumed that if the lake rose to the level of the lagoons, they would be abandoned and damages would be ignored.

2.2 Summary of Economic Analysis Investigation for Feature *2*: City of Devils Lake

2.2.0 Flood Protection Strategy

The Economic Analysis of Devils Lake Alternatives indicated that the flood protection strategy with the largest net benefits for City of Devils Lake was incremental levee construction.

2.2.1 General Information

Feature Type: Community

Location: The City of Devils Lake is located in north central North Dakota 89 miles west of Grand Forks and 121 miles east of Minot on US Highway 2. It is the county seat for Ramsey County. The city is located along a portion of the north shore of Devils Lake and is currently protected by a levee that was constructed by the Corps. The accompanying Figure 2.2-1 shows the feature's location and approximate extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: The City of Devils Lake is a community of 7,222 people (based on 2000 census).

Significance: The City of Devils Lake is important because it is the largest city between Grand Forks and Minot and ranks as the 11th largest city in North Dakota.

Damages: The flooding of the City of Devils Lake would result in the following damages:

- loss of homes
- loss of historical buildings
- loss of commercial properties
- loss of public property including parks and land owned by Ramsey County and City of Devils Lake
- loss of Devils Lake Cemetery
- loss of schools including Minnie H Elementary School, Sweetwater Elementary, Prairieview Elementary School, Central Middle School, Harmony House, Lake Area Vo-Tech Center, North Dakota School for the Deaf
- loss of churches including Assembly of God Church, Christ Free Lutheran Church, St. Joseph Catholic Church, Lakewood Bible Camp Assembly of God
- loss of tax revenues

- loss of Devils Lake Airport.

Owner/Sponsor: The Devils Lake City Commission is responsible for managing and maintaining the City of Devils Lake.

Lead Federal Agency: Corps would take the lead for the City of Devils Lake for any flood protection work that may take place. Federal Emergency Management Agency (FEMA) would coordinate relocation of structures.

2.2.2 Feature Protection

History of Flood Protection: In the past, flood protection for City of Devils Lake has consisted of levee construction and incremental levee raises, road raises and relocations. The City of Devils Lake levee was raised and extended in recent years under emergency authority.

General Protection Strategy: The Economic Analysis identified and evaluated several different approaches for protecting the City of Devils Lake. These included:

- continued levee raises to protect the city
- relocation of the affected structures

Protection Strategy by Lake Level: The Economic Analysis of Devils Lake considered various protection strategies, with flood-protection decisions being made at various lake levels as Devils Lake continued to rise. Figure 2.2-2 shows the decision tree for the City of Devils Lake. As shown on Figure 2.2-2, the stepwise approach to flood protection for the City of Devils Lake consisted of the following:

1. At lake elevation 1449, a decision would be made as to whether all of the structures below 1453 should be relocated or the existing levee raised to a top at 1460 to protect these structures. The first increment of the relocation strategy also includes raising the sections of ND Highway 20 and US Highway 2 that are behind the levee up to 1468.

2. If incremental relocation was selected at the first action level, at lake elevation 1452, a decision would be made as to whether to relocate structures between elevations 1453 and 1458 or relocate all structures below 1464.

   If the levee were raised at the first action level, at lake elevation 1452, a decision would be made as to whether the structures below 1464 should be relocated or the existing levee raised to a top at 1465 to protect these structures.

3. If incremental relocation was selected at the second action level, at lake elevation 1457, all structures below 1464 would be relocated.

If the levee were raised at the second action level, at lake elevation 1457, a decision would be made as to whether the structures below 1464 should be relocated or the existing levee raised to a top at 1470 to protect these structures.

Two maximum protection strategies were analyzed at the first action level: relocating all structures below elevation 1464 or raising the existing levee top to 1470. (Note that for the Economic Analysis of Devils Lake, the decision regarding relocation of structures is made at a time when the lake is one foot below the low structure elevation. The decision regarding whether or not to raise a levee is made at a time when the lake is one foot below the existing level of protection.)

Interdependencies: The protection of the City of Devils Lake is related to the protection of the following features:

- Feature 10: Canadian Pacific Railroad (City of Devils Lake to Harlowe)
- Feature 11: Burlington Northern Railroad (Along US Highway 2)
- Feature 13: US Highway 2
- Feature 15: ND Highway 57 (between BIA Highway 1 and US Highway 281)
- Feature 18: ND Highway 19
- Feature 20: ND Highway 20 (North of the City of Devils Lake)
- Feature 21: ND Highway 20 (City of Devils Lake Levee to ND Highway 57)
- Feature 22: ND Highway 20 (ND Highway 57 to Tokio)

Table 2.0-1, mentioned earlier in this report, provides a summary of the interdependencies among the features.

2.2.3 Feature Economics

Damages: For the City of Devils Lake, the damages resulting from flooding were estimated up to the maximum lake level (1463). The damage computations for the City of Devils Lake are summarized in the accompanying Table 2.2-1.

The first portion of the table shows the damages that are associated with each action level (1449, 1452, and 1457), each representing damages within a range of lake levels. The second portion of the table is a breakdown of the damages associated with each action level. Damages listed include residential, commercial, church, school, and city structures, as well as utilities, airport, and a cemetery.

Unit costs for all the damage computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for the City of Devils Lake are listed in the City of Devils Lake Economic Analysis Assumptions listing, attached to this Section 2.2.

Costs: The costs of providing flood protection for the City of Devils Lake are detailed in the accompanying Table 2.2-2. Unit costs, data sources, and relevant assumptions are listed.

The first portion of the table shows the costs associated with relocation and levee raises at each action level (1449, 1452, and 1457). The second portion of the table is a breakdown of the costs associated with each strategy and each action level. Strategies include incremental relocation and incremental levee raise.

Unit costs for all the cost computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for the City of Devils Lake are listed in the City of Devils Lake Economic Analysis Assumptions listing, attached to this Section 2.2.

2.2.4 Results of Economic Analysis

The results of the Economic Analysis for the City of Devils Lake are listed in Table 2.2-3.

Stochastic Analysis Results: The stochastic analysis indicated that the flood protection strategy with the largest net benefits for the City of Devils Lake was three incremental levee raises. This strategy is highlighted on the decision tree (Figure 2.2-2). The annual net benefits for this strategy were greater than zero ($4,771,300). The BCR for this strategy was greater than one (6.71). These results indicate that this strategy is economically justified. The stochastic results are averages over 10,000 traces.

Results for Specific Scenarios: In the economic analysis, flood protection strategies were also analyzed for three specific climate futures. For the City of Devils Lake, the identified strategy and the economic indices for each of the three climate futures are as follows:

- Wet Future – For the wet future, the flood protection strategy with the largest net benefits was shown to be three incremental levee raises. For this strategy, the net benefits were $11,735,600 and the BCR was 4.33, indicating that this strategy was economically justified.
- First Moderate Future – For the first moderate future, the flood protection strategy with the largest net benefits was shown to be three incremental levee raises. For this strategy, the net benefits were $4,711,600 and the BCR was 18.32, indicating that this strategy was economically justified.

- Second Moderate Future – For the second moderate future, the flood protection strategy with the largest net benefits was shown to be three incremental levee raises. For this strategy, the net benefits were $7,843,400, and the BCR was 5.27, indicating that this strategy was economically justified.

Data: 1997 USGS Digital Ortho Quad

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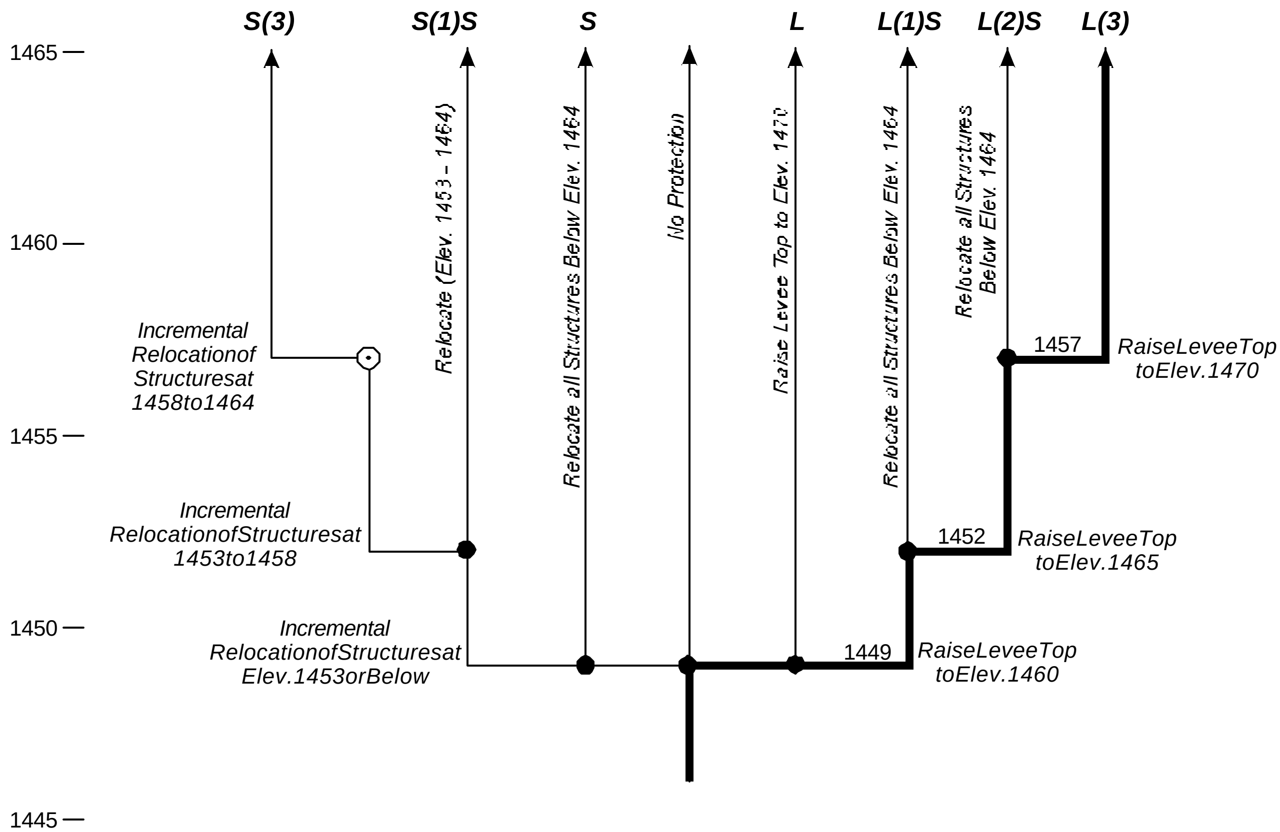

FloodProtectionStrategy

Decisionrequiredatthispoint

Triggerpointforaction,nodecisionneeded

L(1) Incrementalleveeraise(numberoftimes)

L LeveeraisetoElev.1470

S(1) Structurerelocation(numberoftimes)

S RelocateallstructuresbelowElev.1464

Figure2.2-2

DECISION TREE
FEATURE 2:CITYOFDEVILSLAKE
DevilsLakeInfrastructure ProtectionStudy

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Table 2.2-1

Flood Damages
Feature 2: City of Devils Lake
Devils Lake Infrastructure Protection Study

DAMAGES

Action Level	Lake Elevation	Structure Elevation Range	Structures and Infrastructure
	(MSL)	(MSL)	(THOUSANDS)
AL1	1449	Below 1453	$177,259
AL2	1452	1453 - 1458	$50,462
AL3	1457	1458 - 1464	$77,659

DAMAGE BREAKDOWN

AL1: Lake Elevation 1447					AL2: Lake Elevation 1451					AL3: Lake Elevation 1456				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Assessed Residential and Commercia	1	LS	###########	$124,065	Assessed Residential and Commercia	1	LS	$34,373,000	$34,373	Assessed Residential and Commercia	1	LS	$67,083,000	$67,083
Churches and Schools	1	LS	$7,540,000	$7,540	Utilities	1	LS	$9,769,000	$9,769	Utilities	1	LS	$8,782,000	$8,782
Utilities	1	LS	$33,160,000	$33,160	City Property	1	LS	$1,916,000	$1,916	City Property	1	LS	$1,794,000	$1,794
Airport	1	LS	$11,837,000	$11,837	Cemetary	1	LS	$4,404,000	$4,404					
City Property	1	LS	$613,000	$613										
Cemetary	1	LS	$44,000	$44										
Total				**$177,259**	**Total**				**$50,462**	**Total**				**$77,659**

Notes:

1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.

Table 2.2-2

Flood Protection Costs

Feature 2: City of Devils Lake

Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Action Level	Lake Elevation	S(3) Incremental Relocation at AL1,AL2,AL3	S(1)S Incremental Relocation at AL1; Relocate All Structures at AL2	S Relocate All Structures at AL1	L Maximum Protection Levee Raise at AL1	L(1)S Raise Levee at AL1; Relocate All Structures at AL2	L(2)S Raise Levee at AL1, AL2; Relocate All Structures at AL3	L(3) Raise Levee at AL1, AL2, AL3
	(MSL)	(THOUSANDS)						
AL1	1449	$199,536	$199,536	$318,597	$81,442	$9,595	$9,595	$9,595
AL2	1452	$46,681	$119,061	$0	$0	$318,597	$46,476	$46,476
AL3	1457	$72,380	$0	$0	$0	$0	$318,597	$25,371

COST BREAKDOWN

Strategy		Lake Elevation 1449					Lake Elevation 1452					Lake Elevation 1457				
		S(3)					S(3)					S(3)				
		S(1)S					S(1)S									
		S														
		L(1)S														
		L(2)S														
Strategy		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Incremental Relocation																
		Assessed Residential &					Assessed					Assessed				
	Move	Commercial	1	LS	$109,668	$109,668	Residential &	1	LS	$27,385	$27,385	Residential &	1	LS	$59,430	$59,430
		Churches and Schools	1	LS	$7,403	$7,403	Utilities	1	LS	$12,974	$12,974	Utilities	1	LS	$11,126	$11,126
		Utilities	1	LS	$42,153	$42,153	City Property	1	LS	$1,949	$1,949	City Property	1	LS	$1,824	$1,824
		Airport	1	LS	$15,712	$15,712	Cemetary	1	LS	$4,373	$4,373					
		City Property	1	LS	$608	$608										
		Cemetary	1	LS	$13	$13										
		Subtotal				$175,557	Subtotal				$46,681	Subtotal				$72,380
	Road Raise	US 2 - Segment 971 - 2600' from 1465 to 1470														
		Fabric Liner	28,306	SY	$1.25	$35										
		Aggregate Base Course	2,239	CY	$20.00	$45										
		Fill	57,296	CY	$4.50	$258										
		Riprap	18,870	CY	$20.00	$377										
		Bituminous	4,195	TON	$45.00	$189										
		US 2 - Segment 969 - 3900' from 1465 to 1470														
		Fabric Liner	42,458	SY	$1.25	$53										
		Aggregate Base Course	3,358	CY	$20.00	$67										
		Fill	85,944	CY	$4.50	$387										
		Riprap	28,305	CY	$20.00	$566										
		Bituminous	6,292	TON	$45.00	$283										
		Subtotal				$2,260										
		Highway 20 - 1 Mile from 1435 to 1468														
		Fabric Liner	225,002	SY	$1.25	$281										
		Aggregate Base Course	4,547	CY	$20.00	$91										
		Fill	1,671,413	CY	$4.50	$7,521										
		Riprap	150,001	CY	$20.00	$3,000										
		Bituminous	8,518	TON	$45.00	$383										
		Highway 20 - 1 Mile from 1440 to 1468														
		Fabric Liner	195,087	SY	$1.25	$244										
		Aggregate Base Course	4,547	CY	$20.00	$91										
		Fill	1,281,280	CY	$4.50	$5,766										
		Riprap	130,058	CY	$20.00	$2,601										
		Bituminous	8,518	TON	$45.00	$383										
		Subtotal				$20,362										
		1998 Total				$22,622										
		2001 Total (add inflation)				$23,980										
		Total				**$199,536**	**Total**				**$46,681**	**Total**				**$72,380**
		L														
		L(1)S														
		L(2)S					L(2)S									
		L(3)					L(3)					L(3)				
Incremental Levee Raise																
	Levee	Performance/Payment Bond	1	JB	$29,664	$30	Performance/Paymen	1	JB	$142,935	$143	Performance/Payment	1	JB	$89,802	$90
		Clearing & Grubbing	0	AC	$1,925	$0	Clearing & Grubbing	20	AC	$1,925	$39	Clearing & Grubbing	10	AC	$1,925	$19
		Removals	0	AC	$825.00	$0	Removals	20	AC	$825.00	$17	Removals	10	AC	$825.00	$8
		Stripping	0	CY	$1.25	$0	Stripping	106,000	CY	$1.25	$133	Stripping	16,000	CY	$1.25	$20
		Inspection Trench	0	LF	$3.75	$0	Inspection Trench	8,500	LF	$3.75	$32	Inspection Trench	8,500	LF	$3.75	$32
		Impervious Fill	154,583	CY	$4.40	$680	Impervious Fill	#######	CY	$4.40	$14,079	Impervious Fill	456,940	CY	$4.40	$2,011
		Bedding	43,976	CY	$35.00	$1,539	Bedding	86,051	CY	$35.00	$3,012	Bedding	98,826	CY	$35.00	$3,459
		Riprap	82,455	CY	$45.00	$3,710	Riprap	161,362	CY	$45.00	$7,261	Riprap	185,299	CY	$45.00	$8,338
		Sand Drain	0	CY	$20.00	$0	Sand Drain	185,000	CY	$20.00	$3,700	Sand Drain	0	CY	$20.00	$0
		Topsoil (4")	14,753	CY	$1.25	$18	Topsoil (4")	107,852	CY	$1.25	$135	Topsoil (4")	25,029	CY	$1.25	$31
		Seed	27	AC	$900	$24	Seed	201	AC	$900	$181	Seed	47	AC	$900	$42
		Pump Station	0	EA	$1,000,000	$0	Pump Station	0	EA	$1,000,000	$0	Pump Station	0	EA	########	$0
		Subtotal				$6,002	Subtotal				$28,730	Subtotal				$14,051
		Contingency (30%)				$1,801	Contingency (30%)				$8,619	Contingency (30%)				$4,215
		Subtotal w/ Contingency				$7,803	Subtotal w/ Contingency				$37,349	Subtotal w/ Contingency				$18,266
		Engineering and Design (6%)				$468	Engineering and Design (6%)				$2,241	Engineering and Design (6%)				$1,096
		Supervision and Administration (10%)				$780	Supervision and Administration (10%)				$3,735	Supervision and Administration (10%)				$1,827
		1998 Total				$9,051	1998 Total				$43,325	1998 Total				$21,188
		2001 Total (add inflation)				$9,594	2001 Total (add inflation)				$45,924	2001 Total (add inflation)				$22,460
		2001 Adjusted Total				$9,595	2001 Adjusted Total				$45,925	2001 Adjusted Total				$22,427
							Pump Modifications	I	JB		$21	Pump Modifications	1	JB	########	$2,944
							Runway Extensions	I	JB		$530					
		Total				**$9,595**	**Total**				**$46,476**	**Total**				**$25,371**

ANNUAL OPERATION AND MAINTENANCE COSTS

Action Level	Lake Elevation	Levee Maintenance
	(MSL)	(THOUSANDS)
AL1	1449	$6
AL2	1452	$7
AL3	1457	$11

Notes:

1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. The costs for the Relocate All Structures at AL1 strategy (S) is equal to the sum of all relocations that have not been included in incremental relocations.

Table 2.2 - 3

Economic Analysis of Strategies for City of Devils Lake (Feature 2)

Stochastic Analysis (ST)
Mean Value over 10,000 Traces (Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit - Cost Ratio
		Levee Raise	O&M	Relocation	Total	Damages	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C	D = A + B + C	E	F = E	G = F(No Protection) - F(S) *	H = G - D	I= G/D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$5,607,400	$5,607,400	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$8,628,400	$8,628,400	$0	$0	$5,607,400	-$3,021,100	0.65
L	Raise Levee Top to 1470	$2,205,700	$4,600	$0	$2,210,300	$0	$0	$5,607,400	$3,397,100	2.54
L(1)S	1 Levee Raise: Then Relocate	$259,900	$1,500	$3,292,800	$3,554,200	$0	$0	$5,607,400	$2,053,200	1.58
L(2)S	2 Levee Raises: Then Relocate	$740,200	$2,100	$1,170,100	$1,912,400	$0	$0	$5,607,400	$3,695,000	2.93
L(3)	3 Levee Raises	$833,400	$2,700	$0	$836,100	$0	$0	$5,607,400	$4,771,300	6.71
S(1)S	1 Incremental Relocation: Then Relocate All Remaining	$0	$0	$6,634,500	$6,634,500	$0	$0	$5,607,400	-$1,027,100	0.85
S(3)	3 Incremental Relocations	$0	$0	$6,152,200	$6,152,200	$0	$0	$5,607,400	-$544,900	0.91

Wet Future Scenario (WF)
(Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit - Cost Ratio
		Levee Raise	O&M	Relocation	Total	Damages	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C	D = A + B + C	E	F = E	G = F(No Protection) - F(S) *	H = G - D	I= G/D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$15,259,300	$15,259,300	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$18,804,800	$18,804,800	$0	$0	$15,259,300	-$3,545,400	0.81
L	Raise Levee Top to 1470	$4,807,000	$10,300	$0	$4,817,300	$0	$0	$15,259,300	$10,442,000	3.17
L(1)S	1 Levee Raise: Then Relocate	$566,300	$1,200	$14,686,200	$15,253,700	$0	$0	$15,259,300	$5,500	1.00
L(2)S	2 Levee Raises: Then Relocate	$2,708,700	$2,800	$10,136,100	$12,847,600	$0	$0	$15,259,300	$2,411,700	1.19
L(3)	3 Levee Raises	$3,515,900	$7,700	$0	$3,523,700	$0	$0	$15,259,300	$11,735,600	4.33
S(1)S	1 Incremental Relocation: Then Relocate All Remaining	$0	$0	$17,265,600	$17,265,600	$0	$0	$15,259,300	-$2,006,300	0.88
S(3)	3 Incremental Relocations	$0	$0	$16,231,900	$16,231,900	$0	$0	$15,259,300	-$972,600	0.94

Moderate Future 1 Scenario (M1)
(Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit - Cost Ratio
		Levee Raise	O&M	Relocation	Total	Damages	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C	D = A + B + C	E	F = E	G = F(No Protection) - F(S) *	H = G - D	I= G/D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$4,983,800	$4,983,800	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$8,957,600	$8,957,600	$0	$0	$4,983,800	-$3,973,800	0.56
L	Raise Levee Top to 1470	$2,289,800	$4,600	$0	$2,294,400	$0	$0	$4,983,800	$2,689,300	2.17
L(1)S	1 Levee Raise: Then Relocate	$269,800	$2,300	$0	$272,100	$0	$0	$4,983,800	$4,711,600	18.32
L(2)S	2 Levee Raises: Then Relocate	$269,800	$2,300	$0	$272,100	$0	$0	$4,983,800	$4,711,600	18.32
L(3)	3 Levee Raises	$269,800	$2,300	$0	$272,100	$0	$0	$4,983,800	$4,711,600	18.32
S(1)S	1 Incremental Relocation: Then Relocate All Remaining	$0	$0	$5,610,100	$5,610,100	$0	$0	$4,983,800	-$626,300	0.89
S(3)	3 Incremental Relocations	$0	$0	$5,610,100	$5,610,100	$0	$0	$4,983,800	-$626,300	0.89

Moderate Future 2 Scenario (M2)
(Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit - Cost Ratio
		Levee Raise	O&M	Relocation	Total	Damages	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C	D = A + B + C	E	F = E	G = F(No Protection) - F(S) *	H = G - D	I= G/D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$9,680,300	$9,680,300	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$14,686,200	$14,686,200	$0	$0	$9,680,300	-$5,006,000	0.66
L	Raise Levee Top to 1470	$3,754,200	$7,900	$0	$3,762,100	$0	$0	$9,680,200	$5,918,100	2.57
L(1)S	1 Levee Raise: Then Relocate	$442,300	$1,500	$9,528,600	$9,972,500	$0	$0	$9,680,300	-$292,300	0.97
L(2)S	2 Levee Raises: Then Relocate	$1,832,300	$4,500	$0	$1,836,800	$0	$0	$9,680,300	$7,843,400	5.27
L(3)	3 Levee Raises	$1,832,300	$4,500	$0	$1,836,800	$0	$0	$9,680,300	$7,843,400	5.27
S(1)S	1 Incremental Relocation: Then Relocate All Remaining	$0	$0	$12,758,800	$12,758,800	$0	$0	$9,680,300	-$3,078,600	0.76
S(3)	3 Incremental Relocations	$0	$0	$10,594,100	$10,594,100	$0	$0	$9,680,300	-$913,800	0.91

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.375% and rounded to the nearest $100.
*Total benefits are calculated as the totall damages incurred for the "No Protection strategy" minus the totall damages for the strategy implemented (F(S)).

Attachment to 2.2:
City of Devils Lake Economic Analysis Assumptions

A. General Assumptions

1. The area included in the City of Devils Lake feature is the land currently protected by the levees and the area within the Devils Lake city limits.

2. For relocation strategies, structures were assumed to be relocated to high ground north and/or east of the existing city. A precise location was not determined, since the cost of relocation would not be significantly different.

3. Existing levees were assumed to be built to elevation 1457 (top of levee), based on plans for work performed in 1998 (*Devils Lake, ND Bi-Weekly Report*, St. Paul District Corps of Engineers, January 22, 1998).

4. The value of land outside of the Devils Lake city limits was estimated to be $400 per acre (*Corps of Engineers*, April, 2001)

5. The values of the properties described below were determined in 1998. These values were updated for inflation by multiplying them by 1.09, which accounts for an inflation rate of 3% per year from 1998 to February 2001. This inflation rate was obtained from the Devils Lake City Assessor.

   a. The value of land for airport relocation was estimated at $500 per acre in 1998. The updated value is $545 per acre.

   b. The estimated value of commercial property within the Devils Lake city limits was $10,000 per acre in 1998. The updated value is $10,900 per acre.

   c. The estimated value of parkland within the Devils Lake city limits was $5,000 per acre in 1998. The updated value is $5,450.

6. The cost of rebuilding or relocating utility systems and associated features was included in relocation strategies. These costs do not address the costs of demolition of the existing features. Detailed review of demolition costs was beyond the scope of this study.

7. For all relocation strategies, raising portions of both ND Highway 20 and US Highway 2 behind the levee to the maximum level was included in the relocation costs at the first action level when a relocation strategy was chosen. The analysis assumed these sections of highways behind the existing levees was raised in one increment up to elevation 1468. US Highway 2 was assumed to be relocated to higher land adjacent to the Burlington Northern Railroad tracks, for close proximity to the high ground in the downtown area.

B. Levees

1. A decision was assumed to be made when the lake is 1 foot below the design level of protection (i.e., 1 foot below the lower limit of the required freeboard of a levee).

2. It was assumed that the existing levees are built with adequate base to raise the levee to elevation 1460. The parameters used to design the existing levees allow for a 15-foot top width at elevation 1460, with a 6H:1V lakeward slope and 3H:1V landward slope.

3. Proposed incremental levee raises to elevation 1460 were based on plans by the Corps of Engineers.

4. The freeboard for the existing levee is 7 feet with the top of levee at 1457.

5. The levee raise from elevation 1460 to 1470 will require filling on the landward side of the existing levee. The estimated costs of a levee raise from elevation 1460 to 1465 included adequate overbuild for a future raise to elevation 1470. The top width of the levee at elevation 1465 would be 60 feet.

6. The cost of stripping additional topsoil between each levee raise was considered to be incidental. The cost of stripping topsoil to extend the levee on undisturbed ground was included.

7. Based on a brief review of an air photo, 9,000 linear feet of tree removal was estimated to be required above elevation 1460. The costs for the levee raise from elevation 1460 to 1465 included the cost of clearing 20 acres to widen the levee base to the maximum width and extend the levee over previously undisturbed areas. The costs for the levee raise from elevation 1465 to 1470 included the cost of clearing 10 acres to extend the levee over previously undisturbed areas.

8. The costs of incremental levee raises and pump modifications were determined in 1998. These costs were updated for inflation by multiplying it by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001.

C. Residential and Commercial Properties

1. In 1998, the assessed values of residential and commercial structures were obtained from the municipal GIS database. These values were increased based on data from the City of Devils Lake Assessor for the period from 1998 to February 2001. Values were multiplied by a factor of 1.075 (to account for new development of 2.5% per year) and a factor of 1.09 (to account for inflation of 3% per year).

2. For relocation strategies, a decision was assumed to be made when the lake is 1 foot below the level of the low structure. This was based on the existing process which is influenced by the availability of movers, the estimated lake rise each spring, and the restrictions of funding programs. Depending on the slope of the land, wave action may affect structures several feet above the lake's level.

3. On the 1994 USGS quadrangle map, small buildings outside the Devils Lake city limits were assumed to denote single residential dwellings. Each square was counted as a single residence, unless field investigation indicated otherwise (i.e., structure was already gone or abandoned or the structure was a garage instead of residential dwelling). Additional residences that were not indicated on the quadrangle map were counted based on visits to the city.

4. Subdivision boundaries in the Creel Township area were identified based on visits to the city (*Devils Lake Creel Township Levee Assessment*, Barr Engineering Company, August 20, 1997). Average values of residences within these boundaries were obtained from the 1997 report. These values were multiplied by a factor of 1.075 (to account for new development of 2.5% per year) and a factor of 1.09 (to account for inflation of 3% per year) for the increase during the period from 1998 to February 2001.

5. The value of residences outside of the Devils Lake city limits (described in item number 3 above) were estimated based on the 1998 residential average within the city (from the municipal GIS database). These values were multiplied by a factor of 1.075 (to account for new development of 2.5% per year) and a factor of 1.09 (to account for inflation of 3% per year) for the increase during the period from 1998 to February 2001. Specific assumptions for the 1998 values included:

   a. If a residence was part of "small tracts of land" in the Midland Atlas, the average value used for the residential dwelling was $41,950 (lot value and improvement value). The updated value is $49,950.

   b. If a residence was on land with an identified owner in the Midland Atlas, the lot value was estimated by multiplying the parcel size shown in the Midland Atlas by $300 per acre (the agricultural land value). This lot value was added to $34,664 per residential dwelling, the estimated average improvement value, to give a total value for lot and improvements. The updated values are $400 per acre for lots and $40,620 for improvements.

   c. In the absence of flood protection measures, damages were assumed to occur at the lowest elevation at which a residential structure was affected by rising lake levels. Land could be affected at lower elevation but this land loss was not included until the dwelling was affected. Seepage into basements was not considered.

6. On the 1994 quadrangle map, larger plain rectangles (not small squares) outside the Devils Lake city limits were assumed to denote commercial buildings. Each rectangle was counted as a single commercial building.

7. Commercial buildings outside of the Devils Lake city limits were assumed to have average values based on the 1998 commercial average within the city (from the municipal GIS database). These values were multiplied by a factor of 1.075 (to account for new development of 2.5% per year) and a

factor of 1.09 (to account for inflation of 3% per year) for the increase during the period from 1998 to February 2001. Specific assumptions for the 1998 values included:

a. If a commercial building was part of "small tracts of land" in the Midland Atlas, the average value of the commercial building used was $94,785 (lot value plus improvement value). The updated value is $111,060.

b. If a commercial building was on land with an identified owner in the Midland Atlas, the lot value was estimated by multiplying the parcel size shown in the Midland Atlas by $300 per acre (the agricultural land value). This lot value was added to $74,743 per commercial building (the estimated average improvement value) to give an estimated total value of lot and improvement. The updated values are $400 per acre for lots and $87,580 for improvements.

c. In the absence of flood protection measures, damages were assumed to occur at the lowest elevation at which a structure was affected by rising lake levels. Land could be affected at lower elevations but these losses were only included at the elevation at which the structure began to be affected.

8. The area identified as "Bible Camp" on the 1994 quadrangle map was outlined based on field observation (Lakewood Bible Camp). The structures within the Lakewood Bible Camp boundaries were not included in the above residential or commercial values.

   a. All but one small building (small square on topo) was at an elevation greater than 1465. Although the buildings in the Camp are on high ground, the Bible Camp would be surrounded by the lake without the existing levee and it would not have access. Therefore, for all relocation strategies, the entire camp was assumed to be damaged at the first relocation action level, with damages assumed to occur at that level.

   b. The replacement cost of the Bible Camp was assumed to be the insured value of the structures. In 1998, the insured value was $2,462,000. This value was multiplied by a factor of 1.09, to account for inflation of 3% per year, during the period from 1998 to February 2001. The updated value is $2,683,580.

9. The value of the golf course was assumed to be $2,300,000 (*Devils Lake Creel Township Levee Assessment*, Barr Engineering Company, August 20, 1997). This value is in 1998 dollars; therefore it was multiplied by a factor of 1.09, to account for inflation of 3% per year, during the period from 1998 to February 2001. The updated value is $2,500,000.

10. Land in the Midland Atlas that had a total acreage, but did not have structures noted on the quadrangle map, was valued at $400 per acre (the agricultural land value as stated above).

11. In the absence of flood protection measures, damages to structures were assumed to occur at the lowest elevation at which structures were affected, except as follows:

    a. Damages to the golf course were assumed to occur at the first action level where the levee is not raised. The golf course is protected by the city levee and damages would only happen if the levee was abandoned; the first potential abandonment would be at action level 1450. Assuming there was no levee at elevation 1450, a large portion of the golf course would be inundated by the lake, and the golf course was assumed to be inoperable.

    b. Damages to land that contains no structures or improvements were estimated to occur at the lowest elevation at which the land was affected. Damages to land were grouped between action levels, and were assumed to occur when the water surface is 1 foot below the action level. This may 'front-end load' the damages; however, only small parcels of land were analyzed for this feature, and the effects of this assumption are not expected to be significant. Conversely, wave action could affect land several feet above the lake's level and, therefore, actual damages might occur before the lake reaches the parcel's lowest elevation.

    c. The Bible Camp is excepted as noted in item 8 above.

12. Land outside the city limits that is within the assumed levee alignment and above the maximum lake level would become isolated and inaccessible if the levee is not raised and the lake rises to 1463. The values for the land and structures in these isolated areas were calculated and included as damages for relocation strategies. Conversely, for strategies where levees remain in place, these amounts were included as damages prevented.

13. In the absence of the existing levee, the subdivision located southwest of the intersection of ND Highway 20 and Ramsey County 1 would become isolated and surrounded by the lake above elevation 1440. However, the access road is relatively short and the costs of raising the access would be minimal compared to the costs of relocating the subdivision. Because ND Highway 20 within the levee is assumed to remain open with or without the levee in place, the area was assumed to have access even if the existing levee was removed. For relocation strategies, relocation of these houses was assumed to occur at the elevation of the structure (not the elevation at which the area becomes isolated). Similarly, for levee strategies, damages prevented for this area were assumed to occur at the elevation of the structures.

14. All structures and property below elevation 1450 were grouped to compute damages in the absence of flood protection measures. For relocation strategies, when the lake reaches action level 1449 (1 foot below the level of protection of the existing levee), all structures within the current levee alignment that are below elevation 1450 would be relocated.

15. In the absence of flood protection measures, damages to structures and property were assumed to be equal to the depreciated replacement values discussed above. Conversely, if protection is provided, all or a portion of the potential damages would be treated as damages prevented.

16. The costs for relocating or rebuilding commercial structures were estimated to be 100% of the assessed value of the improvement and 100% of the assessed value of the lot.

17. The costs for relocation of residential structures were estimated to be 70% of the assessed value of the improvement and 100% of the assessed value of the lot.

D. Public Properties

1. The values and costs for the public property described below in items 2 – 6, were determined in 1998. These 1998 dollars were multiplied by a factor of 1.09 to account for inflation of 3% per year during the period from 1998 to February 2001. This inflation rate was obtained in conversations with the Ramsey County Assessor and the City of Devils Lake Assessor.

2. Estimated values for property owned by Ramsey County were based on telephone conversations with staff at the County Assessor's office.

3. Estimated values for properties owned by the City of Devils Lake were based on telephone conversations with Gary Martinson, City Assessor.

4. The value of public properties was based on the estimated insured replacement values of the structures.

5. In the absence of flood protection measures, relocation or rebuild costs were assumed to equal the value of the structure.

6. Relocation costs for the cemetery are based on telephone conversation with the City Assessor. The cemetery charges $300 to move a burial. Assuming that relocating the cemetery would result in further moving distances, $500 was used for moving each burial. Relocation included the cost to purchase 80 acres of new land at $300 per acre and relocating 8,000 burials at $500 each. The updated values are $400 per acre for land and $545 per burial for relocating. In the absence of flood protection measures, damages to the cemetery included 80 acres at $1,000 per acre and 8,000 burials at $500 each. The updated values are $1,090 per acre for land and $545 per burial for relocating.

E. School and Churches

1. All costs and values described below in items 2 – 6 were determined in 1998. These 1998 dollars were multiplied by a factor of 1.075 (to account for new development of 2.5% per year) and a factor of 1.09 (to account for inflation of 3% per year) for the increase during the period from 1998 to

February 2001. These inflation rates were obtained in conversations with the City of Devils Lake Assessor.

2. For schools and churches, insured values of the structure were used when available. According to the City Assessor, insured replacement values are typically much greater than assessed values. Therefore, land values were not added to determine the total value. Insured values for several schools were obtained from telephone conversations with the Devils Lake school administrator. Insured values for several churches were obtained from telephone conversations with church administrators. All other school and church values were estimated using *RS Means Building Construction Cost Data, 56th Annual Edition,* 1998. If only total insured values were provided, the structure was assumed to have a value of 75% of the total insured value.

3. Insured values included the value of only the structures. The insured value of contents was not included in the insured value.

4. Several institutions between elevation 1460 and 1462 were assumed to be relocated or rebuilt for the relocation strategies. It appears likely that several of these facilities could be protected with a ring dike or levee more economically than they could be relocated, provided that access is maintained. However, this study did not analyze this option.

5. The relocation or rebuild cost was assumed to be 100% of insured value of the structure.

6. In the absence of flood protection measures, damages were assumed to be 100% of insured value of the structure.

F. Utilities

1. The costs of relocating utilities described below in items 2 – 9 were obtained in 1998. These 1998 dollars were updated for inflation by multiplying it by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001.

2. Individual utility service connections were included with assessed lot values. However, the cost to replace utility infrastructure was calculated separately for relocation strategies and to determine the benefit provided for flood protection measures.

3. Gas main costs associated with relocation strategies were based on discussions with Montana Dakota Utilities (MDU) staff. In the absence of flood protection measures, damages were assumed to equal the relocation or rebuild cost. Costs were distributed on a per-user basis.

4. Relocation costs for electrical infrastructure were based on conversations with Otter Tail Power staff. In the absence of flood protection measures, damages were assumed to equal the relocation cost.

5. Relocation costs for telephone infrastructure were based on conversations with North Dakota Telephone Company staff. In the absence of flood protection measures, damages were assumed to equal the relocation cost. The costs did not include the cost of fiber optic cables. Costs were distributed on a per-user basis.

6. For relocation strategies, costs for the wastewater treatment system were based on conversations with the City Engineer and the City Assessor and on Environmental Protection Agency (EPA) construction costs. The cost includes construction of a new wastewater treatment plant and distribution system and the closing of the existing lagoons. In the absence of flood protection measures, damages were assumed to be 75% of the rebuild cost, due to depreciation of the existing system. Although land application disposal was assumed in this study, the City Engineer indicated that a lagoon system may be required.

7. For strategies that include levee protection, it was assumed that the lagoons would continue to function as the lake continues to rise. A brief analysis of groundwater in the area indicates that it would not affect the operation of lagoons in the area *(Hydrogeology of the Shallow Water Table at the City of Devils Lake, North Dakota*, North Dakota State Water Commission, 1998).

8. For relocation strategies, costs for the water treatment system were based on conversations with the City Engineer and the City Assessor and on EPA construction costs. The cost includes construction of a new plant, a 500,000-gallon water tower, a 3,000,000-gallon reservoir, four supply wells, and a distribution system. The actual system may include tapping into and treating surface water. However, the scope of the study did not include review of specific treatment system alternatives. In the absence of flood protection measures, advance replacement of infrastructure was assumed to be 75% of the rebuild cost to factor in the effects of depreciation.

9. For relocation strategies, costs for the storm sewer system were based on a conversation with the City Engineer. The cost was based on converting the $7,000,000 upgrade performed in 1978 to 1998 costs using historical cost indexes (*RS Means Building Construction Cost Data, 56th Annual Edition*, 1998). The estimated cost to rebuild the system was $14,968,000. The updated cost is $15,866,080. In the absence of flood protection measures, damages were assumed to be 75% of the rebuild cost due to depreciation. The costs were distributed on a per-user basis.

G. Devils Lake Airport

1. The costs to relocate the airport and build a runway extension, described below in items 2 – 6, were determined in 1998. These costs were updated for inflation by multiplying the airport by a factor of 1.09 (to account for an inflation rate of 3% per year) and the runway extension was multiplied by the ENR Construction Cost Index of 1.06 (to account for 6% inflation from 1998 to February 2001). The inflation rate was obtained from the City of Devils Lake Assessor.

2. Airport relocation costs were developed based on telephone conversations with the Airport District Engineer and the airport consultant at the firm of Kadrmis, Lee & Jackson.

3. Airport relocation costs included 15% for various engineering, administrative, and environmental review costs. In addition to engineering design, the relocation of the new airport would require detailed studies including preparation of an Environmental Impact Statement (EIS) to assess the social, economic and environmental effects of the project.

4. Due to depreciation, the value of the existing airport ("damages prevented") was assumed to be 75% of the value to relocate/rebuild.

5. Raising the existing levee to elevation 1457 would require extending Runway 321 by 170 feet due to FAA clearance regulations. The runway extension cost of $261,000 was included in the levee cost at action level 1449. The updated cost is $276,660. This cost does not include the cost to demolish sections of the existing runway that would no longer be useable.

6. Raising the levee to elevation 1465 would require additional expansion of the runway. The estimated cost of $500,000 was assumed to occur at action level 1452. The updated cost is $530,000. Extending the runway in smaller increments was not feasible due to disruption of air traffic. This cost does not include the cost to demolish sections of the existing runway that would no longer be useable.

2.3 Summary of Economic Analysis Investigation for Feature 3: Fort Totten

2.3.0 Flood Protection Strategy

The Economic Analysis of Devils Lake indicated that the flood protection strategy with the largest net benefits for Fort Totten was incremental relocation.

2.3.1 General Information

Feature Type: Community

Location: Fort Totten is located along the south side of Devils Lake on the Spirit Lake Nation reservation in Benson County. The majority of the town is adjacent to ND Highway 57 just northeast of the intersection of ND Highway 57 and BIA Highway 1. The accompanying Figure 2.3-1 shows the feature's location, location of structures, approximate extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: Fort Totten is an unincorporated community of 952 people (based on 2000 census).

Significance: The value of all the communities in this study is high because of the density of infrastructure in this primarily rural section of North Dakota. Although Fort Totten has not been significantly affected by the rising lake level to date, it is a relatively large community and major center of activity for the Spirit Lake Nation.

Damages: The flooding of Fort Totten would result in the following damages:

- Loss of 14 homes at lake elevation of 1463

When the water level reaches 1451, one (1) home would be impacted. When the water level reaches 1456, a total of six (6) homes would be impacted, and when the water level reaches 1463, a total of fourteen (14) homes would be impacted. "Impacted" means water levels would be above or within one foot of the foundation of the house.

Owner/Sponsor: The Spirit Lake Nation is responsible for managing and maintaining Fort Totten.

Lead Federal Agency: The Corps of Engineers would take the lead for Fort Totten for any flood protection work that may take place. Federal Emergency Management Agency (FEMA) would coordinate relocation of structures.

2.3.2 Feature Protection

History of Flood Protection: In the past, flood protection for Fort Totten has consisted of relocating the sewage lagoons. The sewage lagoons located near the lake in the Fort Totten area are no longer in use. New sewage lagoons were constructed on higher ground immediately west of this location. The old lagoons near the lake had a majority of the wastewater removed by pumping into the new sewage lagoons. There is still a direct pumping pipeline from the old disposal ponds to the new ponds. The pipeline serves two purposes:

1. To pump the remaining wastewater from the old eastern sewage lagoons to the new western sewage lagoons.
2. To be used in case of an emergency where the new western sewage lagoons would be unusable.

It was assumed that the eastern ponds will not be needed during flooding events and can be abandoned if necessary.

General Protection Strategy: The Economic Analysis of Devils Lake identified and evaluated several different approaches for protecting Fort Totten. These included:

- Construction of levees to protect a small number of homes along the northeast side of Fort Totten. Since the cost of these levees would be far in excess of the estimated value of the structures at each action level, the levee protection strategy was not pursued further.
- Relocation of the affected homes.

Protection Strategy by Lake Level: The Economic Analysis of Devils Lake considered various protection strategies, with flood-protection decisions being made at various lake levels as Devils Lake continued to rise. Figure 2.3-2 shows the decision tree for Fort Totten. As shown on Figure 2.3-2, the stepwise approach to flood protection for Fort Totten consisted of the following:

1. At lake elevation 1447, a decision would be made as to whether the structures between 1448 and 1452 should be relocated or a levee constructed to protect these structures. The preliminary analysis indicated that construction of a levee for protecting Fort Totten was greater than the value of the property and was not economically justified, and therefore it was not analyzed.
2. At lake elevation 1451, relocation would occur for structures between elevations 1452 and 1457.
3. At lake elevation 1456, relocation would occur for structures between elevations 1457 and 1464.

The maximum protection strategy that was analyzed at the first action level was relocating all structures below elevation 1464. (Note that for the Economic Analysis of Devils Lake, the decision regarding relocation of structures or whether or not to construct a levee is made at a time when the lake is one foot below the low structure elevation.)

Interdependencies: Flood protection for Fort Totten is related to the protection of the highways that serve it. These highways include:

- Feature 14: ND Highway 57 (between ND Highway 20 and BIA Highway 1)
- Feature 15: ND Highway 57 (between BIA Highway 1 and US Highway 281)
- Feature 21: ND Highway 20 (City of Devils Lake Levee to ND Highway 57)
- Feature 22: ND Highway 20 (ND Highway 57 to Tokio)
- Feature 24: BIA Highway 6

These highways are critical for Fort Totten in that they provide the main transportation routes in and out of the community.

Table 2.0-1, mentioned earlier in this report, provides a summary of the interdependencies among the features.

2.3.3 Feature Economics

Damages: For Fort Totten the damages resulting from flooding were estimated up to the maximum lake level (1463). The damage computations for Fort Totten are summarized in the accompanying Table 2.3-1.

The first portion of the table shows the damages that are associated with each action level (1447, 1451, and 1456), each representing damages within a range of lake levels. The second portion of the table is a breakdown of the number of houses associated with each action level and cost of damages. Damages listed include houses only. The action levels identified (1447, 1451, and 1456) should not be confused with the three reference lake levels (1447, 1454, and 1463).

Unit costs for all the damage computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for Fort Totten are listed in the Fort Totten Assumptions listing, appended to this Section 2.3.

Costs: The costs of providing flood protection for Fort Totten are detailed in the accompanying Table 2.3-2. Unit costs, data sources, and relevant assumptions are listed.

The first portion of the table shows the cost of relocating the houses at each action level (1447, 1451, and 1456). The second portion of the table is a breakdown of the number of houses associated with each action level and their costs. The second portion of the table also includes the cost of protecting the houses with a levee constructed to 1470.

Unit costs for all the cost computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for Fort Totten are listed in the Fort Totten Assumptions listing, appended to this Section 2.3.

2.3.4 Results of Economic Analysis

The results of the Economic Analysis for Fort Totten are listed in Table 2.3-3.

Stochastic Analysis Results: The stochastic analysis indicated that the flood protection strategy with the largest net benefits for Fort Totten was three incremental relocations of structures. This strategy is highlighted on the decision tree (Figure 2.3-2). The annual net benefits for this strategy were less than zero (-$1,000). The BCR for this strategy was less than one (0.91). These results indicate that this strategy is not economically justified. The stochastic results are averages over 10,000 traces.

Results for Specific Scenarios: In the economic analysis, flood-protection strategies were also analyzed for three specific climate futures. For Fort Totten, the identified strategy and the economic indices for each of the three climate futures are as follows:

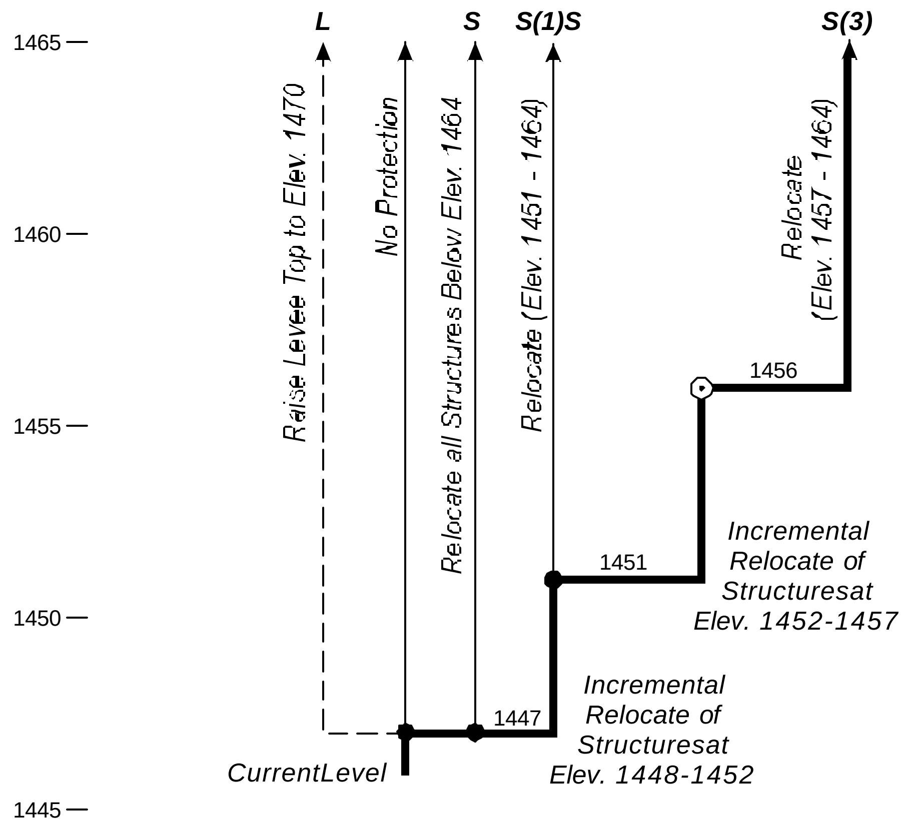
- Wet Future – For the wet future, the flood protection strategy with the largest net benefits was shown to be three incremental relocations of structures. For this strategy, the net benefits were -$3,600 and the BCR was 0.91, indicating that this strategy was not economically justified.
- First Moderate Future – For the first moderate future, the flood protection strategy with the largest net benefits was shown to be three incremental relocations of structures. For this strategy, the net benefits were -$400, and the BCR was 0.91, indicating that this strategy was not economically justified.
- Second Moderate Future – For the second moderate future, the flood protection strategy with the largest net benefits was shown to be three incremental relocations of structures. For this strategy, the net benefits were -$1,300, and the BCR was 0.91, indicating that this strategy was not economically justified.

Figure 2.3-1

LOCATION MAP
FEATURE 3: FORT TOTTEN
Devils Lake Infrastructure
Protection Study

Barr: Arcview 3.1, OPT 2615, i:\client\devilslake\gis\dlp\features\communities\03_forttotten\project\basemap_03.apr, Layout: Layout: Section 2 Location Map, lkp, Thu Dec 05 10:52:39 2002

Data: 1997 USGS Digital Ortho Quad



FloodProtectionStrategy

Decisionrequiredatthispoint

Triggerpointforaction,nodecisionneeded

L(1) Incrementalleveeraise(numberoftimes)

L LeveeraisetoElev.1470

S(1) Structurerelocation(numberoftimes)

S RelocateallstructuresbelowElev.1464

Strategy notanalyzed

Figure2.3-2

DECISION TREE
FEATURE 3:FORTTOTTEN
DevilsLakeInfrastructure ProtectionStudy

Table 2.3-1

Flood Damages
Feature 3: Fort Totten
Devils Lake Infrastructure Protection Study

DAMAGES

Action Level	Lake Elevation	Structure Elevation Range	Structures and Infrastructure
	(MSL)	(MSL)	(THOUSANDS)
AL1	1447	Below 1452	$62
AL2	1451	1452 - 1457	$310
AL3	1456	1457 - 1464	$496

DAMAGE BREAKDOWN

AL1: Lake Elevation 1447					AL2: Lake Elevation 1451					AL3: Lake Elevation 1456				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
House	1	EA	$62,000	$62	House	5	EA	$62,000	$310	House	8	EA	$62,000	$496
Total				**$62**	**Total**				**$310**	**Total**				**$496**

Notes:

1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.

Table 2.3-2

Flood Protection Costs
Feature 3: Fort Totten
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Action Level	Lake Elevation	S Relocate All Structures at AL1	S(1)S Incremental Relocation at AL1; Relocate All Structures at AL2	S(3) Incremental Relocation at AL1, AL2, AL3
	(MSL)	(THOUSANDS)		
AL1	1447	$952	$68	$68
AL2	1451	$0	$884	$340
AL3	1456	$0	$0	$544

COST BREAKDOWN

Strategy		S														
		S(1)S					S(1)S									
		S(3)					S(3)					S(3)				
		Lake Elevation 1447					Lake Elevation 1451					Lake Elevation 1456				
Incremental Relocation		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
	Move	House	1	EA	$68,000	$68	House	5	EA	$68,000	$340	House	8	EA	$68,000	$544
		Subtotal				$68	Subtotal				$340	Subtotal				$544
		Total				**$68**	**Total**				**$340**	**Total**				**$544**

Strategy		Lake Elevation 1447				
Maximum Protection Levee Raise*		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
	Levee	Performance/Pay	1	JB	$46,807	$47
		Impervious Fill	552,992	CY	$4.40	$2,433
		Bedding	42,805	CY	$35.00	$1,498
		Riprap	80,259	CY	$45.00	$3,612
		Sand Drain	49,925	CY	$20.00	$999
		Topsoil (4")	6,804	CY	$1.25	$9
		Seed	13	AC	$876	$11
		Pump Station	1	EA	$800,000	$800
		Subtotal				$9,408
		Contingency (30%)				$2,822
		Subtotal w/ Contingency				$12,231
		Engineering and Design (6%)				$734
		Supervision and Administration (10%)				$1,223
		1998 Total				$14,188
		2001 Total (add inflation)				$14,191
		2001 Adjusted Total				$14,190
	Pump Station	Pump Station	3	EA	$283,000	$849
		Subtotal				$849
		Total				**$15,039**

* This maximum protection levee raise cost was not analyzed in our conceptual model due to its excessive cost.

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. The costs for the Relocate All Structures at AL1 strategy (S) is equal to the sum of all relocations that have not been included in incremental relocations.
4. 2001 Total for levee cost is equal to the 1998 Total cost minus the pump station cost multiplied by 6% to increase for inflation.
5. 2001 Adjusted Total adjusts detailed cost breakdown to match the 2001 totals.

Table 2.3 - 3

Economic Analysis of Strategies for Fort Totten
(Feature 3)

Strategy		Stochastic Analysis (ST) Mean Value over 10,000 Traces (Annual)								
		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
		Levee Raise	O&M	Relocation	Total	Damages	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C	D = A + B + C	E	F = E	G = F(No Protection) - F(S) *	H = G - D	I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$10,200	######	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$59,600	$59,600	$0	$0	$10,200	-$49,400	0.17
S(1)S	1 Incremental Relocation: Then Relocate All Re	$0	$0	$15,900	$15,900	$0	$0	$10,200	-$5,700	0.64
S(3)	3 Incremental Relocations	$0	$0	$11,200	$11,200	$0	$0	$10,200	-$1,000	0.91

Strategy		Wet Future Scenario (WF) (Annual)								
		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
		Levee Raise	O&M	Relocation	Total	Damages	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C	D = A + B + C	E	F = E	G = F(No Protection) - F(S) *	H = G - D	I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$36,900	######	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$59,800	$59,800	$0	$0	$36,900	-$22,800	0.62
S(1)S	1 Incremental Relocation: Then Relocate All Re	$0	$0	$47,600	$47,600	$0	$0	$36,900	-$10,700	0.78
S(3)	3 Incremental Relocations	$0	$0	$40,500	$40,500	$0	$0	$36,900	-$3,600	0.91

Strategy		Moderate Future 1 Scenario (M1) (Annual)								
		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
		Levee Raise	O&M	Relocation	Total	Damages	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C	D = A + B + C	E	F = E	G = F(No Protection) - F(S) *	H = G - D	I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$3,900	$3,900	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$59,800	$59,800	$0	$0	$3,900	-$55,900	0.07
S(1)S	1 Incremental Relocation: Then Relocate All Re	$0	$0	$4,300	$4,300	$0	$0	$3,900	-$400	0.91
S(3)	3 Incremental Relocations	$0	$0	$4,300	$4,300	$0	$0	$3,900	-$400	0.91

Strategy		Moderate Future 2 Scenario (M2) (Annual)								
		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
		Levee Raise	O&M	Relocation	Total	Damages	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C	D = A + B + C	E	F = E	G = F(No Protection) - F(S) *	H = G - D	I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$13,800	######	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$59,800	$59,800	$0	$0	$13,800	-$46,000	0.23
S(1)S	1 Incremental Relocation: Then Relocate All Re	$0	$0	$32,400	$32,400	$0	$0	$13,800	-$18,600	0.43
S(3)	3 Incremental Relocations	$0	$0	$15,100	$15,100	$0	$0	$13,800	-$1,300	0.91

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.375% and rounded to the nearest $100.
* Total benefits are calculated as the total damages incurred for the "No Protection strategy" minus the total damages for the strategy implemented (F(S)).

Attachment to 2.3:
Fort Totten Economic Analysis Assumptions

A. General Assumptions

1. Estimated damages included only the homes in the immediate area of Fort Totten. According to the League of Cities office in Bismarck, the area is not incorporated. The few homes outside of the immediate area were included in computations for Feature 8.1: Devils Lake Rural Areas.

B. Levee

1. A decision was assumed to be made when the lake is 1 foot below the design level of protection (i.e., 1 foot below the lower limit of the required freeboard of a levee).

2. In Fort Totten, most of the houses to be protected are arranged linearly and parallel to the land contours. The levees required to protect the homes would therefore be extremely long. A preliminary cost estimate (1998 dollars) indicated that the cost of construction and maintenance of these levees would be approximately $14 million to protect to the maximum lake level. The cost of incremental levee raises would be $2.5 and $8.5 million at action levels 1446 and 1451, respectively. Since the cost of these levees would be far in excess of the estimated value of the structures at each action level, the levee protection strategy was not pursued further. Therefore, only relocation strategies were analyzed for Fort Totten.

3. For levee protection, it was assumed that 5 feet of freeboard would be required at action levels 1447 and 1451, and that 7 feet of freeboard would be required at the maximum lake level. The assumed freeboard was based on the proposed freeboard for the City of Devils Lake and the high waves predicted for this area.

C. Residential and Commercial Properties

1. For relocation strategies, a decision was assumed to be made when the lake is 1 foot below the level of the low structure. This was based on the existing process which is influenced by the availability of movers, the estimated lake rise each spring, and the restrictions of funding programs. Depending on the slope of the land, wave action may affect structures several feet above the lake's level.

2. The average value of a house in Fort Totten was estimated to be $62,000. This figure was obtained from the Federal Emergency Management Agency (FEMA) and represents the average value of a house located on the Spirit Lake Nation Reservation. The value for each house was determined for FEMA by certified flood insurance adjusters and was based on total habitable square footage of the buildings and standardized real estate appraisals (*FEMA*, personal communication, March, 2001). These values did not include the value of land on which the houses were located.

3. Relocation cost for a house was estimated to be $68,000. This cost was obtained from the North Dakota-North Central Planning Council and represents the average cost to relocate a residence during the buyout program conducted in Churchs Ferry (2000). The $68,000 includes the following costs: demolition of the existing house, purchase of an equivalent house in a nearby community, purchase of a lot, legal, appraisal, and management fees. It was assumed relocation costs would be approximately the same in Fort Totten as they were in Churchs Ferry.

4. The disposal ponds located near the lake in the Fort Totten area are no longer in use. New disposal ponds were constructed on higher ground west of this location. The old ponds near the lake had a majority of the wastewater removed by pumping into the new disposal ponds, according to Neil Austin of the Spirit Lake Nation Indian Health Service. There is still a direct pumping pipeline from the old disposal ponds to the new ponds. The pipeline serves two purposes:

   a. To pump the remaining wastewater from the old eastern ponds to the new western ponds.

   b. To be used in case of an emergency where the new western ponds would be unusable.

   Therefore, it was assumed that the eastern ponds will not be needed during flooding events and can be abandoned if necessary.

2.4 Summary of Economic Analysis Investigation for Feature 4: Minnewaukan

2.4.0 Flood Protection Strategy

The Economic Analysis of Devils Lake Alternatives indicated that the flood protection strategy with the largest net benefits for the City of Minnewaukan was incremental levee construction.

2.4.1 General Information

Feature Type: Community

Location: The City of Minnewaukan is located on the west side of Devils Lake in Benson County, ND. The community of Fort Totten lies to the southeast and the community of Churchs Ferry lies to the north of the City of Minnewaukan. Currently, US Highway 281 (South of US Highway 2) passes through the city limits. The accompanying Figure 2.4-1 shows the feature's location and approximate extents, and the inundation extents at the reference lake levels (1447, 1454, and 1463).

Description: Minnewaukan is a city with a population of 318 (based on 2000 census), and is the County Seat of Benson County. The city covers approximately 250 acres and includes residential and commercial development, municipal facilities (public library, courthouse, fairgrounds, etc.), utility infrastructure (roads, sewers, electrical, telephone, etc.), and transportation infrastructure (local streets and US Hwy 281 (South of US Highway 2)).

Significance: Minnewaukan is important because it is a densely populated area that contains property of significant value and historical significance. The value of all the communities in this study is high because of the density of the infrastructure in this primarily rural section of North Dakota. The surrounding infrastructure includes major transportation routes for nearby population and industry. Minnewaukan contains County Seat facilities including the county fairgrounds and courthouse. There are numerous commercial and residential properties that would be affected by rising lake levels, particularly for lake levels above 1455.

Damages: The flooding of the City of Minnewaukan would result in the following damages:

- Loss of homes – The total value of homes at the 1451 lake level is minimal. The number and combined value of homes increases significantly at about elevation 1455. Approximately 90% of the single-family homes in the city lie above 1455. The majority of the property at risk in the city is located between 1456 and 1463.

- Loss of historical buildings – The Benson County Courthouse and Grace Episcopal Church are listed in the National Register of Historic Places. Existing damage estimates include only the assessed value of the property and do not account for HTRW considerations. The Benson County Courthouse has an estimated value in excess of $1,800,000, making it the most expensive single property in the city, and accounting for over 10% of the total value of all property within the city.

- Loss of commercial and municipal properties – As with homes in the city, the majority of commercial and municipal properties at risk are between 1456 and 1463. Significant properties in the city include the public school, the grain elevator, the museum, and three churches. These items taken together account for approximately 10% of the total value of all property within the city.
- Loss of tax revenues.
- Loss of access on major highways and rail lines.

Owner/Sponsor: The City of Minnewaukan, City Council is responsible for managing and maintaining day-to-day administration of the city.

Lead Federal Agency: The Corps of Engineers would take the lead for the City of Minnewaukan for any flood protection work that may take place. Federal Emergency Management Agency (FEMA) would coordinate relocation of structures.

2.4.2 Feature Protection

History of Flood Protection: In the past, flood protection for the City of Minnewaukan has consisted of the following:

- Moving the sewage treatment ponds to higher ground (1995). The top of the dike around the sewage treatment ponds is believed to be above 1463.
- Installation of a back-up water supply line from the water plant north of town, extending south from the water plant to the west of the city, then extending east through the city to the water tower.
- Installation of drainage features to prevent flooding from the unnamed coulee on the northwest side of the city, including enlarging culverts under the railroad and highways on the north end of town.
- Abandoning certain portions of the county fairgrounds.

General Protection Strategy: The Economic Analysis identified and evaluated several different approaches for protecting the City of Minnewaukan. These included:

- Construction of a levee around the city

- Relocation of the affected structures through FEMA funding programs
- Combination levee and relocation of US Highway 281 (South of US Highway 2) as a flood barrier

Several different flood barrier options were reviewed and two of the options were evaluated to determine the least costly alternative as a flood barrier option:

- Levee with riprap for wave protection
- Levee with roller-compacted concrete (RCC) for wave protection

Protection Strategy by Lake Level: The Economic Analysis of Devils Lake considered various protection strategies, with flood protection decisions being made at various lake levels as Devils Lake continued to rise. Figure 2.4-2 shows the decision tree for the City of Minnewaukan. As shown on Figure 2.4-2, the stepwise approach to flood protection for the City of Minnewaukan consisted of the following:

1. At lake elevation 1447, all structures below elevation 1451 would be relocated.
2. At lake elevation 1450, a decision would be made as to whether the structures between 1451 and 1456 should be relocated or a levee should be constructed to a top of 1461 to protect these structures.
3. If incremental relocation was selected at the first action level, at lake elevation 1455, all structures below 1464 would be relocated.

   If the levee were constructed at the first action level, at lake elevation 1455, a decision would be made as to whether the structures between 1451 and 1464 should be relocated or the existing levee raised to a top at 1468 to protect these structures.

Two maximum protection strategies were analyzed at the first action level: relocating all structures below elevation 1464 or raising the existing levee top to 1468. (Note that for the Economic Analysis of Devils Lake, the decision regarding relocation of structures or whether or not to construct a levee is made at a time when the lake is one foot below the low structure elevation. The decision regarding whether or not to raise a levee is made at a time when the lake is one foot below the existing level of protection.)

Interdependencies: Protection of the City of Minnewaukan is related to the protection of US Highway 281 (South of US Highway 2). US Highway 281 passes through the city limits and is the major thoroughfare for traffic. Relocation or raise of US Highway 281 will affect access to the city and will also affect the location of the city in any relocation alternatives. In addition, previous studies considered using US Highway 281 as a combination road and levee, thus affecting funding and location of the road/levee.

Table 2.0-1, mentioned earlier in this report, provides a summary of the interdependencies among the features.

2.4.3 Feature Economics

Damages: For the City of Minnewaukan, the damages resulting from flooding were estimated up to the maximum lake level (1463). The damage computations for the City of Minnewaukan are summarized in the accompanying Table 2.4-1.

The first portion of the table shows the damages that are associated with each action level (1450 and 1455), each representing damages within a range of lake levels. The second portion of the table is a breakdown of the damages associated with each action level. Damages listed include a wide range of structures, including homes, apartments, churches, a library, courthouse, city lots, land, businesses, a school, a trailer court, grain elevator, a museum, and a park.

Unit costs for all the damage computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for the City of Minnewaukan are listed in the City of Minnewaukan Economic Analysis Assumptions listing, attached to this Section 2.4.

Costs: The costs of providing flood protection for the City of Minnewaukan are detailed in the accompanying Table 2.4-2. Unit costs, data sources, and relevant assumptions are listed.

The first portion of the table shows the cost for each strategy for each action level (1450 and 1455). This includes:

- Incremental relocation
- Maximum protection levee at first action level
- Raise levee at first action level and then relocate all structures
- Incremental levee raise
- Relocate all structures at first action level

The second portion of the table is a breakdown of the strategy costs for each strategy and each action level.

Unit costs for all the cost computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for the City of Minnewaukan are listed in the City of Minnewaukan Economic Analysis Assumptions listing, attached to this Section 2.4.

2.4.4 Results of Economic Analysis

The results of the Economic Analysis for the City of Minnewaukan are listed in Table 2.4-3.

Stochastic Analysis Results: The stochastic analysis indicated that the flood protection strategy with the largest net benefits for the City of Minnewaukan was two incremental levee raises. This strategy is highlighted on the decision tree (Figure 2.4-2). The annual net benefits for this strategy were greater than zero ($58,500). The BCR for this strategy was greater than one (1.52). These results indicate that this strategy was economically justified. The stochastic results are averages over 10,000 traces.

Results for Specific Scenarios: In the economic analysis, flood protection strategies were also analyzed for three specific climate futures. For the City of Minnewaukan, the identified strategy and the economic indices for each of the three climate futures are as follows:

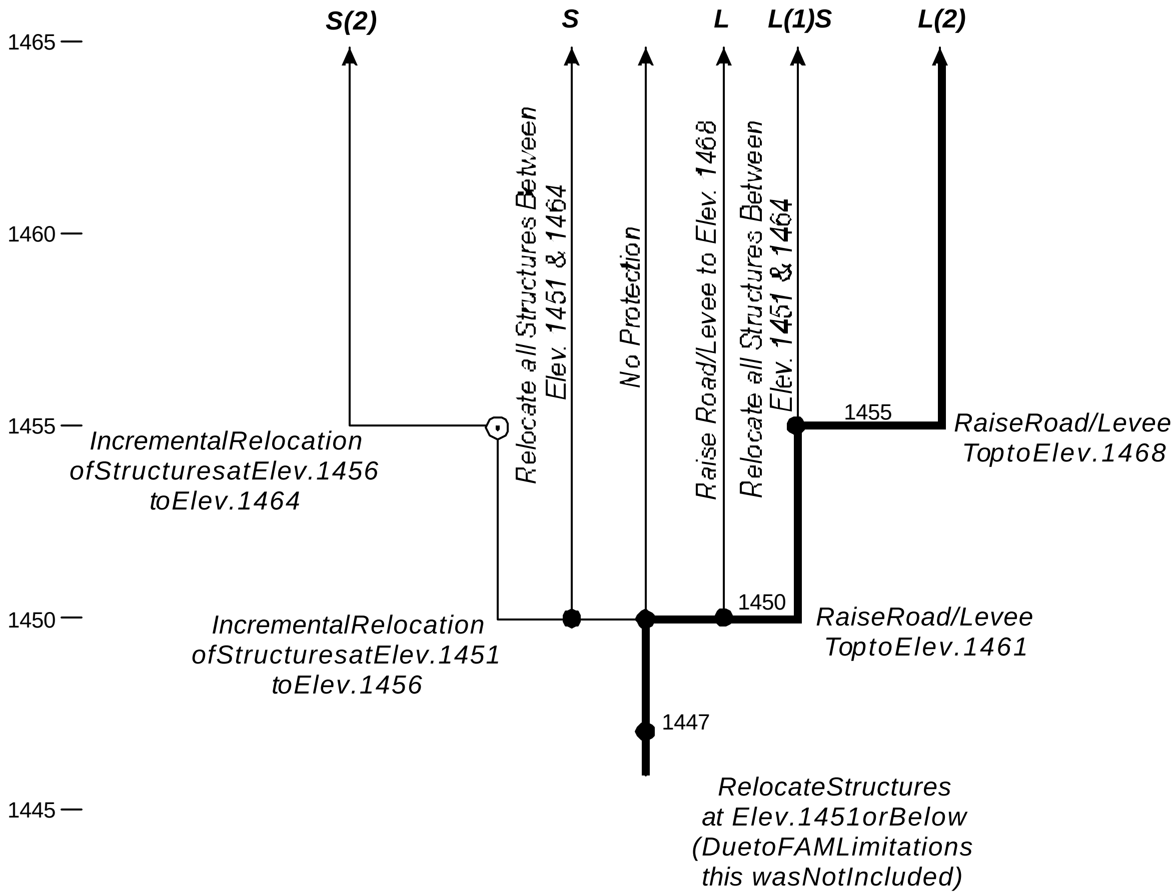
- Wet Future – For the wet future, the flood protection strategy with the largest net benefits was shown to be two incremental levee raises. For this strategy, the net benefits were $434,400 and the BCR was 2.09, indicating that this strategy was economically justified.
- First Moderate Future – For the first moderate future, the flood protection strategy with the largest net benefits was shown to be incremental relocations of structures. For this strategy, the net benefits were $27,200, and the BCR was 1.24, indicating that this strategy was economically justified.
- Second Moderate Future – For the second moderate future, the flood protection strategy with the largest net benefits was shown to be incremental relocations of structures. For this strategy, the net benefits were $44,500, and the BCR was 1.24, indicating that this strategy was economically justified.

Figure 2.4-1

LOCATION MAP
FEATURE 4: CITY OF MINNEWAUKAN
Devils Lake Infrastructure Protection Study

Data: 1997 USGS Digital Ortho Quad

Barr: Arcview 3.1, OPT2615, i:\client\devilslake\gis\dlip\features\communities\04_minnewaukan\project\basemap_04.apr, Layout: Layout: Section 2 Figure, lkp, Thu Dec 05 10:46:09 2002



(thick line)	FloodProtectionStrategy
(filled dot)	Decisionrequiredatthispoint
(circled dot)	Triggerpointforaction,nodecisionneeded
L(1)	Incrementalleveeraise(numberoftimes)
L	LeveeraisetoElev.1468
S(1)	Structurerelocation(numberoftimes)
S	RelocateallstructuresbelowElev.1464

Figure2.4-2

DECISION TREE
FEATURE 4:CITYOFMINNEWAUKEN
DevilsLakeInfrastructure ProtectionStudy

P:\34136\20\DECISIONTREES\2002FIGURES\FIGURE2_04.CDR RLG 01-02-03

Table 2.4-1

Flood Damages
Feature 4: City of Minnewaukan
Devils Lake Infrastructure Protection Study

DAMAGES

Action Level	Lake Elevation (MSL)	Structure Elevation Range (MSL)	Structures and Infrastructure (THOUSANDS)
AL1	1450	Below 1456	$4,997
AL2	1455	1451 - 1464	$14,471

DAMAGE BREAKDOWN

Strategy	AL1: Lake Elevation 1447					AL2: Lake Elevation 1450					AL3: Lake Elevation 1455				
	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Incremental Relocation	Church	1	EA	$287,000	$287	House	45	EA	$88,000	$3,960	House	108	EA	$88,000	$9,504
						HUD Unit + Lots	1	EA	$219,070	$219	Business	23	EA	$42,500	$978
							16	EA	$313	$5	Minnewaukan Residences	2	EA	$101,500	$203
						Apartments/Senior Residenc	1	EA	$46,000	$46	Church	3	EA	$287,000	$861
						Business	3	EA	$42,500	$128	Library	1	EA	$43,800	$44
						School	1	EA	$550,000	$550	Courthouse	1	EA	$1,808,900	$1,809
						Lots	194	EA	$313	$61	Lots	391	EA	$313	$122
						Land	21.5	ACR	$400	$9	Land	109.4	ACR	$400	$44
						Trailer Court	1	EA	$19,760	$20	Grain Elevator	1	EA	$750,200	$750
											Museum	1	EA	$125,000	$125
											Park	1	EA	$31,200	$31
	Total				**$287**	**Total**				**$4,997**	**Total**				**$14,471**
Incremental Levee Raise						House	45	EA	$88,000	$3,960	House	108	EA	$88,000	$9,504
						HUD Unit + Lots	1	EA	$219,070	$219	Business	23	EA	$42,500	$978
							16	EA	$313	$5	Minnewaukan Residences	2	EA	$101,500	$203
						Apartments/Senior Residenc	1	EA	$46,000	$46	Church	3	EA	$287,000	$861
						Business	3	EA	$42,500	$128	Library	1	EA	$43,800	$44
						School	1	EA	$550,000	$550	Courthouse	1	EA	$1,808,900	$1,809
						Lots	194	EA	$313	$61	Lots	391	EA	$313	$122
						Land	21.5	ACR	$400	$9	Land	109.4	ACR	$400	$44
						Trailer Court	1	EA	$19,760	$20	Grain Elevator	1	EA	$750,200	$750
											Museum	1	EA	$125,000	$125
											Park	1	EA	$31,200	$31
						Total				**$4,997**	**Total**				**$14,471**

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. Operation and maintenance costs apply to levee strategies, and include operation and maintenance of pumping stations and levee embankments, These costs are incurred annually, each year that the levee remains in place.

Table 2.4-2

Flood Protection Costs

Feature 4: City of Minnewaukan

Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

		S(2)	S	L	L(1)S	L(2)
Action Level	Lake Elevation	Incremental Relocation at AL1, AL2	Relocate all Structures at AL1	Maximum Protection Levee at AL1	Raise Levee at AL1; Relocate All Structures at AL2	Raise Levee at AL1, AL2
	(MSL)	(THOUSANDS)				
AL1	1450	$4,031	$16,342	$7,802	$5,349	$5,349
AL2	1455	$12,311	$0	$0	$16,342	$2,453

COST BREAKDOWN

		S(2)					S(2)				
		S									
		L(1)S									
		Lake Elevation 1450					Lake Elevation 1455				
Strategy		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Incremental Relocation											
	Move	Houses	45	EA	$68,000	$3,060	House @ $68,000/EA	108	EA	$68,000	$7,344
		HUD Unit + Lots	1	EA	$153,349	$153	Business @ $42,500/EA	23	EA	$42,500	$978
			16	EA	$313	$5	Minnewaukan Residences	2	EA	$101,500	$203
		Apartments/Senior Residence	1	EA	$46,000	$46	Church @ $287,000	3	EA	$287,000	$861
		Business @ $42,500/EA	3	EA	$42,500	$128	Library	1	EA	$43,800	$44
		School	1	EA	$550,000	$550	Courthouse	1	EA	$1,808,900	$1,809
		Lots @ $313/EA	194	EA	$313	$61	Lots @ $313/EA	391	EA	$313	$122
		Land @ $400/ACR	21.5	ACR	$400	$9	Land @ $400/ACR	109.4	ACR	$400	$44
		Trailer Court	1	EA	$19,800	$20	Grain Elevator	1	EA	$750,200	$750
							Museum	1	EA	$125,000	$125
							Park	1	EA	$31,200	$31
		Subtotal				$4,031	Subtotal				$12,311
		Total				**$4,031**	**Total**				**$12,311**
		L									
		L(2)					L(2)				
		L(1)S									
Incremental Levee Raise											
	Levee	East Levee					East Levee				
		Performance/Payment Bond	1	JB	$3,573	$4	Performance/Payment Bond	1	JB	$2,639	$2.6
		Stripping (6")	3,593	CY	$1.25	$4	Stripping (6")	1,808	CY	$1.25	$2.3
		Inspection Trench	3,800	LF	$3.75	$14	Inspection Trench	0	LF	$3.75	$0
		Impervious Fill	26,599	CY	$4.22	$112	Impervious Fill	48,349	CY	$4.22	$204
		RCC	11,689	CY	$40.00	$468	RCC	7,941	CY	$40.00	$318
		Topsoil (4")	1,516	CY	$2.08	$3	Topsoil (4")	1,028	CY	$2.08	$2.1
		Seed	3	ACR	$929.17	$3	Seed	2	ACR	$929.17	$1.9
		Pedestrian Handrail	3,800	LF	$29.00	$110	Pedestrian Handrail	0	LF	$29.00	$0
		Subtotal				$718	Subtotal				$531
		Contingency (30%)				$215	Contingency (30%)				$159
		Subtotal w/ Contingency				$934	Subtotal w/ Contingency				$690
		Engineering and Design (15%)				$140	Engineering and Design (15%)				$103
		Supervision and Administration (7.5%)				$70	Supervision and Administration (7.5%)				$52
		Rural Real Estate	2	ACR	$270	$1	Rural Real Estate	1	ACR	$270	$0.3
		Urban Real Estate	2	ACR	$3,485	$9	Urban Real Estate	2	ACR	$3,485	$5.0
		Real Estate Administration (20%)				$2	Real Estate Administration (20%)				$1.1
		East LeveeTotal				$1,155	East LeveeTotal				$851
		West Levee					West Levee				
		Performance/Payment Bond	1	JB	$4,039	$4	Performance/Payment Bond	1	JB	$4,540	$5
		Stripping (6")	4,225	CY	$1.25	$5	Stripping (6")	3,866	CY	$1.25	$5
		Inspection Trench	5,700	LF	$3.75	$21	Inspection Trench	1,700	LF	$3.75	$6
		Impervious Fill	22,056	CY	$4.22	$93	Impervious Fill	60,392	CY	$4.22	$255
		RCC	12,911	CY	$40.00	$516	RCC	14,630	CY	$40.00	$585
		Topsoil (4")	1,628	CY	$2.08	$3	Topsoil (4")	1,946	CY	$2.08	$4
		Seed	3	ACR	$929.17	$3	Seed	4	ACR	$929.17	$4
		Pedestrian Handrail	5,700	LF	$29.00	$165	Pedestrian Handrail	1,700	LF	$29.00	$49
		Subtotal				$812	Subtotal				$913
		Contingency (30%)				$244	Contingency (30%)				$274
		Subtotal w/ Contingency				$1,055	Subtotal w/ Contingency				$1,187
		Engineering and Design (15%)				$158	Engineering and Design (15%)				$178
		Supervision and Administration (7.5%)				$79	Supervision and Administration (7.5%)				$89
		Rural Real Estate	3	ACR	$270	$1	Rural Real Estate	3	ACR	$270	$1
		Urban Real Estate	2	ACR	$3,485	$8	Urban Real Estate	2	ACR	$3,485	$13
		Real Estate Administration (20%)				$2	Real Estate Administration (20%)				$3
		West LeveeTotal				$1,304	West LeveeTotal				$1,470
		1998 Total				$2,458	1998 Total				$2,322
		2001 Total (add inflation)				$2,606	2001 Total (add inflation)				$2,461
	Interior Drainage	Interior Drainage	1	EA	$2,163,400	$2,163					
		Subtotal				$2,163					
	Relocate	House @ $68,000/EA	7	EA	$68,000	$476					
		Business @ $42,500/EA	2	EA	$42,500	$85					
		Trailer Court	1	EA	$19,800	$20					
		Subtotal				$581					
		Total				$5,350	Total				$2,461
		2001 Adjusted Total				**$5,349**	**2001 Adjusted Total**				**$2,453**

ANNUAL OPERATION AND MAINTENANCE COSTS

Lake Elevation	Pump Operation and	Levee Maintenance	Total Operation and
(MSL)	(THOUSANDS)		

1450	$2	$5	$7
1456	$4	$4	$8

Notes:

1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. The maximum protection strategy for this feature is equal to the sum of the incremental relocation costs at each action level.
4. The maximum protection levee raise cost of not analyzed due to its excessive cost.
5. 248 lots were assumed to be saved by the levee. However, up to 52 lots may actually be under the footprint of the levee or outside the levee.
   For this reason, the damages prevented for this strategy may be slightly less than those used in our analysis.
6. For all strategies, a church valued at $277,000 to be moved at Elevation 1447, was not included due to FAM limitations.
4. 2001 Total for levee cost is equal to the 1998 Total cost multiplied by 6% to increase for inflation.
5. 2001 Adjusted Total adjusts detailed cost breakdown to match the 2001 totals.

Table 2.4 - 3

Economic Analysis of Strategies for City of Minnewaukan (Feature 4)

Strategy		Stochastic Analysis (ST) Mean Value over 10,000 Traces (Annual)								
		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$170,700	#######	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$295,400	$295,400	$0	$0	$170,700	-$124,700	0.58
L	Raise Top of Levee to 1468	$141,000	#####	$0	$143,300	$0	$0	$170,700	$27,500	1.19
L(1)S	1 Incremental Levee Raise: Relocae All Structures Belov	$96,700	#####	$90,800	$188,700	$0	$0	$170,700	-$18,000	0.90
L(2)	2 Levee Raises	$110,300	#####	$0	$112,200	$0	$0	$170,700	$58,500	1.52
S(2)	2 Incremental Relocations	$0	$0	$141,300	$141,300	$0	$0	$170,700	$29,500	1.21

Strategy		Wet Future Scenario (WF) (Annual)								
		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$831,500	#######	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$906,700	$906,700	$0	$0	$831,500	-$75,300	0.92
L	Raise Top of Levee to 1468	$432,900	#####	$0	$439,900	$0	$0	$831,400	$391,500	1.89
L(1)S	1 Incremental Levee Raise: Relocae All Structures Belov	$296,800	#####	$625,800	$924,500	$0	$0	$831,500	-$93,000	0.90
L(2)	2 Levee Raises	$390,700	#####	$0	$397,100	$0	$0	$831,500	$434,400	2.09
S(2)	2 Incremental Relocations	$0	$0	$695,100	$695,100	$0	$0	$831,500	$136,300	1.20

Strategy		Moderate Future 1 Scenario (M1) (Annual)								
		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$140,500	#######	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$459,400	$459,400	$0	$0	$140,500	-$319,000	0.31
L	Raise Top of Levee to 1468	$219,400	#####	$0	$222,700	$0	$0	$140,500	-$82,200	0.63
L(1)S	1 Incremental Levee Raise: Relocae All Structures Belov	$150,400	#####	$0	$153,100	$0	$0	$140,500	-$12,600	0.92
L(2)	2 Levee Raises	$150,400	#####	$0	$153,100	$0	$0	$140,500	-$12,600	0.92
S(2)	2 Incremental Relocations	$0	$0	$113,300	$113,300	$0	$0	$140,500	$27,200	1.24

Strategy		Moderate Future 2 Scenario (M2) (Annual)								
		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$230,400	#######	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$753,300	$753,300	$0	$0	$230,400	-$523,000	0.31
L	Raise Top of Levee to 1468	$359,600	#####	$0	$365,400	$0	$0	$230,300	-$135,100	0.63
L(1)S	1 Incremental Levee Raise: Relocae All Structures Belov	$246,600	#####	$0	$251,300	$0	$0	$230,400	-$21,000	0.92
L(2)	2 Levee Raises	$246,600	#####	$0	$251,300	$0	$0	$230,400	-$21,000	0.92
S(2)	2 Incremental Relocations	$0	$0	$185,800	$185,800	$0	$0	$230,400	$44,500	1.24

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.375% and rounded to the nearest $100.

* Total benefits are calculated as the totall damages incurred for the "No Protection stragegy" minus the totall damages for the strategy implemented (F(S)).

Attachment to 2.4:
City of Minnewaukan Economic Analysis Assumptions

A. General Assumptions

1. It was assumed that the low structure in the city lies at elevation 1448, based on maps supplied by the city staff showing curb and gutter elevations, selected survey points, and personal conversations with the County Assessor.

B. Levees

1. A decision was assumed to be made when the lake is 1 foot below the design level of protection (i.e., 1 foot below the lower limit of the required freeboard of a levee).

2. The costs of levee protection did not consider the cost of undefined supplemental protection for higher levels along an unnamed coulee along the northwest city limits during runoff events.

3. Levees were assumed to require 5 feet of freeboard.

4. The levee design was obtained from the *Devils Lake, Minnewaukan Federal Interest Study*, Barr Engineering Company, September 29, 1998. That report provided two options for structural protection: a levee and a road/levee. Continued viability of the City is dependent on not only the levee but also on keeping US Highway 281 open to provide access. If the levee option is chosen, US Highway 281 south of US Highway 2 will be raised.

5. The analysis of incremental levee raises would not allow a relocation of structures prior to construction of the first levee raise. Therefore, the first relocation at elevation 1447.0 was not included in the analysis. The value of this relocation ($0.3 million) is minimal when compared to the total values at higher elevations ($4.0 to $12.3 million).

C. Residential and Commercial Buildings

1. For relocation strategies, a decision was assumed to be made when the lake is 1 foot below the level of the low structure. This was based on the existing process which is influenced by the availability of movers, the estimated lake rise each spring, and the restrictions of funding programs. Depending on the slope of the land, wave action may affect structures several feet above the lake's level.

2. The average value of a house in Minnewaukan is estimated to be $88,000. This figure was obtained from the Federal Emergency Management Agency (FEMA) and represents the average value of rural houses located around Devils Lake, excluding houses on the Spirit Lake Nation Reservation. The value for each house was determined for FEMA by certified flood insurance adjusters and was based on total habitable square footage of the buildings and standardized real estate appraisals (*FEMA*, personal communication, March, 2001). These values did not include the value of the land on which

the houses were located. The $88,000 average was based on rural houses only, therefore houses in the Cities of Minnewaukan and Devils Lake were not included in the analysis. However, the analysis did include many houses in the area surrounding Minnewaukan. Therefore, it was assumed that the average value of a residence in Minnewaukan was same as in the surrounding area.

3. The values and relocation costs for the structures and properties described below are in 1998 dollars. These values and costs were updated for inflation by multiplying them by the ENR Building Cost Index of 1.042. This accounts for 4.2% inflation during the period from 1998 to February 2001. Specific assumptions for the 1998 values included:

   a. For the park and the athletic fields, the same values were used as in the ongoing study for the city. A value of $25,000 was used for the park as well as the athletic fields. The updated value is $26,050.

   b. The value of all churches was approximated using the $275,000 insured value of the structure only for Trinity Lutheran Church. The updated value is $286,550.

   c. The value of the Courthouse was estimated using the 1997 Swift and Marshall Book replacement value for a good Class C building, at $100 per square foot for the top three floors and $74 per square foot for the basement. The courthouse has approximately 14,403 square feet on the top three floors. The basement was assumed to be 4,000 square feet. Therefore, the estimate replacement value of the Courthouse was $1,736,000. The updated value is $1,808,912.

   d. The value of the Museum was estimated at $100,000, based on a conversation with Garvin Plumber, Museum operator, and increased to $120,000 to reflect the depreciated replacement value. The updated value is $125,040.

   e. Costs for the swimming pool, school, and library were estimated using a value of 25% of the low end of the 1997 Means Cost Estimate. The low-end estimates were used based on the comparatively low values of structures in a small city. Since only the square footage for the school was available, the square footage was assumed for the other structures at:

      i. Swimming pool building = 450 square feet

      ii. Library = 2,000 square feet

   f. The estimated values for the structures mentioned above include the value of the lots. According to the City Assessor, each lot had an assessed value of $300. The updated value is $312. The lot sizes of some larger structures were determined from the city map as follows:

      i. West Bay Housing (Individual HUD home) = 16 lots

      ii. Trailer court = 20 lots

4. For relocation strategies, it was assumed that the pool and park were not relocated. The pool is in very poor condition, and has not been used in recent years because of its poor condition.

5. Relocation costs were assumed to be 70% of the assessed value of trailer courts and HUD homes (West Bay units) plus 100% of the assessed values of the lot.

6. Relocation costs for homes were estimated to be $68,000. This cost was obtained from the North Dakota-North Central Planning Council and represents the average cost to relocate a residence during the buyout program conducted in Churchs Ferry (2000). The $68,000 includes the following costs: demolition of the existing house, purchase of an equivalent house in a nearby community, purchase of a lot, and legal, appraisal, and management fees. It was assumed relocation costs would be approximately the same in Minnewaukan as they were in Churchs Ferry.

7. The cost for relocation/rebuilding of commercial and public facilities was assumed to be 100% of the value of the structure and property.

8. The land value for Minnewaukan is estimated to be $400/acre. This value was provided by the Corps of Engineers (April, 2001) and is an estimate of the average value of all land surrounding Devils Lake.

2.5 Summary of Economic Analysis Investigation for Feature 5: St. Michael

2.5.0 Flood Protection Strategy

The Economic Analysis of Devils Lake Alternatives indicated that the flood protection strategy with the largest net benefits for St. Michael was relocation of structures (homes and sewage lagoon).

2.5.1 General Information

Feature Type: Community

Location: St. Michael is located along the south side of Devils Lake in Benson County. The majority of the town is adjacent to BIA Highway 1 just north of the intersection of BIA Highway 1 and BIA Highway 6. The accompanying Figure 2.5-1 shows the feature's location and approximate extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: St. Michael is an unincorporated town. St. Michael has been protected from the rising lake waters by roads that are currently acting as dams (see analysis of Feature 25).

Significance: The value of all the communities in this study is high because of the density of infrastructure in this primarily rural section of North Dakota. Although St. Michael has not been significantly affected by the rising lake level to date, several homes and a sewage lagoon could be affected by rising lake levels.

Damages: The flooding of St. Michael would result in the following damages:

- Loss of 25 homes at 1463
- Loss of a sewage lagoon

Owner/Sponsor: The Spirit Lake Nation is responsible for managing and maintaining St. Michael.

Lead Federal Agency: The Corps of Engineers would take the lead for St. Michael for any flood protection work that may take place. Federal Emergency Management Agency (FEMA) would coordinate relocation of structures.

2.5.2 Feature Protection

History of Flood Protection: In the past, flood protection for St. Michael has consisted of raising berms around the sewage lagoon. The Bureau of Indian Affairs installed additional protection for the St. Michael sewage lagoons in 1997 to prevent damage due to the high lake level. The Economic Analysis estimated the relocation cost for the sewage lagoon to be $159,000.

General Protection Strategy: The Economic Analysis identified and evaluated several different approaches for protecting St. Michael. These included:

- Construction of a levee to protect the most vulnerable (north) part of town. Since the cost of the levee would be far in excess of the estimated value of the structures at each action level, the levee protection strategy was not pursued further.
- Relocation of the town's sewage lagoon and the affected homes.

Protection Strategy by Lake Level: The Economic Analysis of Devils Lake considered various protection strategies, with flood protection decisions being made at various lake levels as Devils Lake continued to rise. Figure 2.5-2 shows the decision tree for St. Michael. As shown on Figure 2.5-2, the stepwise approach to flood protection for St. Michael consisted of the following:

1. At lake elevation 1447, a decision would be made as to whether the structures below 1451 should be relocated or a levee constructed to protect these structures. This first decision would need to be made when the adjacent roads are no longer acting as dams (see analysis of Feature 25). The preliminary analysis indicated that construction of a levee for protecting St. Michael was greater than the value of the property and was not economically justified, and therefore it was not analyzed.
2. At lake elevation 1450, relocation would occur for structures between 1451 and 1456.
3. At lake elevation 1455, relocation would occur for structures between 1456 and 1464.

The maximum protection strategy that was analyzed at the first action level was relocating all structures below 1464. (Note that for the Economic Analysis of Devils Lake, the decision regarding relocation of structures or whether or not to construct a levee is made at a time when the lake is one foot below the low structure elevation.)

Interdependencies: The protection of St. Michael is related to the protection of the highways that serve it. These highways include:

- Feature 23: BIA Highway 1 between ND Highway 57 and BIA Highway 6
- Feature 24: BIA Highway 6 from ND Highway 20 to Fort Totten

These highways are critical for St. Michael in that they provide the main transportation routes in and out of the community.

Table 2.0-1, mentioned earlier in this report, provides a summary of the interdependencies among the features.

2.5.3 Feature Economics

Damages: For St. Michael, the damages resulting from flooding were estimated up to the maximum lake level (1463). The damage computations for St. Michael are summarized in the accompanying Table 2.5-1.

The first portion of the table shows the damages that are associated with action level (1447, 1450, and 1455), each representing damages within a range of lake levels. The second portion of the table is a breakdown of the damages associated with each action level. Damages listed include houses and the sewage lagoon.

Unit costs for all the damage computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for St. Michael are listed in the St. Michael Economic Analysis Assumptions listing, attached to this Section 2.5.

Costs: The costs of providing flood protection for St. Michael are detailed in the accompanying Table 2.5-2. Unit costs, data sources, and relevant assumptions are listed.

The first portion of the table shows the cost of relocations at each action level (1447, 1450, and 1455). The second portion of the table is a breakdown of the relocations associated with each action level and their costs. The second portion of the table also includes the cost of protecting the houses and sewage lagoon with a levee constructed to 1470.

Unit costs for all the cost computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for St. Michael are listed in the St. Michael Economic Analysis Assumptions listing, attached to this Section 2.5.

2.5.4 Results of Economic Analysis

The results of the Economic Analysis for St. Michael are listed in Table 2.5-3.

Stochastic Analysis Results: The stochastic analysis indicated that the flood protection strategy with the largest net benefits for St. Michael was three incremental relocations of structures. This strategy is highlighted on the decision tree (Figure 2.5-2). The annual net benefits for this strategy were less than zero (-$900). The BCR for this strategy was less than one (0.96). These results indicate that this strategy was not economically justified. The stochastic results are averages over 10,000 traces.

Results for Specific Scenarios: In the economic analysis, flood protection strategies were also analyzed for three specific climate futures. For St. Michael, the identified strategy and the economic indices for each of the three climate futures are as follows:

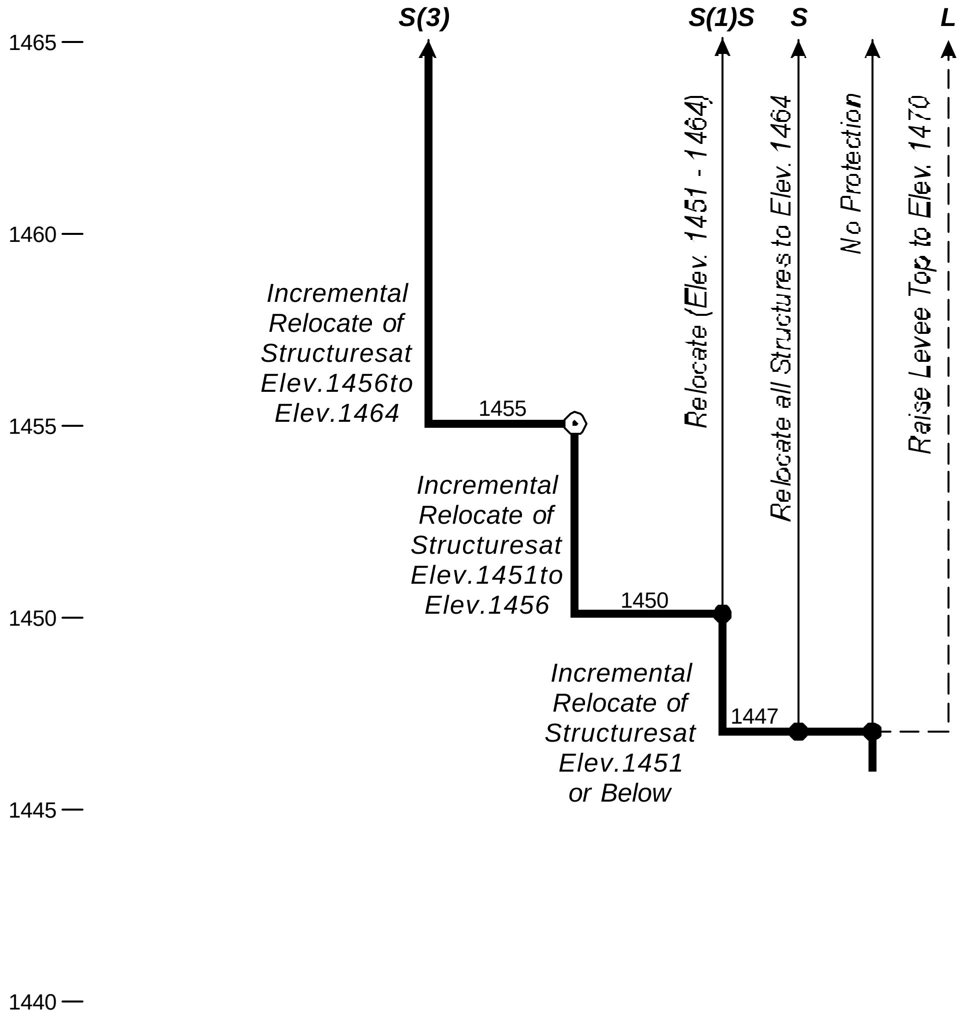
- Wet Future – For the wet future, the flood protection strategy with the largest net benefits was shown to be three incremental relocations of structures. For this strategy, the net benefits were -$5,900 and the BCR was 0.92, indicating that this strategy was not economically justified.
- First Moderate Future – For the first moderate future, the flood protection strategy with the largest net benefits was shown to be incremental relocations of structures. For this strategy, the net benefits were -$200, and the BCR was 0.99, indicating that this strategy was not economically justified.
- Second Moderate Future – For the second moderate future, the flood protection strategy with the largest net benefits was shown to be incremental relocations of structures. For this strategy, the net benefits were -$300, and the BCR was 0.98, indicating that this strategy was not economically justified.

Figure 2.5-1

LOCATION MAP
FEATURE 5: ST. MICHAEL
Devils Lake Infrastructure
Protection Study

Barr: Arcview 3.1, OPT2615, i:\client\devilslake\gis\dlp\features\communities\05_stmichael\project\basemap_05.apr, Layout: Sec 2 2001 Analysis Location Map, lkp, Thu Dec 05 10:47:54 2002

Data: 1997 USGS Digital Ortho Quad



FloodProtectionStrategy

Decisionrequiredatthispoint

Triggerpointforaction,nodecisionneeded

L(1) Incrementalleveeraise(numberoftimes)

L LeveeraisetoElev.1470

S(1) Structurerelocation(numberoftimes)

S RelocateallstructuresbelowElev.1464

——— Strategy notAnalyzed

P:\34\36\020\DECISION TREES\2002 FIGURES\FIGURE2_05.CDR RLG 01-02-03

Figure2.5-2

DECISION TREE
FEATURE 5: ST. MICHAEL
DevilsLakeInfrastructure ProtectionStudy

Table 2.5-1

Flood Damages
Feature 5: St. Michael
Devils Lake Infrastructure Protection Study

DAMAGES

Action Level	Lake Elevation	Structure Elevation Range	Structures and Infrastructure
	(MSL)	(MSL)	(THOUSANDS)
AL1	1447	Below 1451	$159
AL2	1450	1451 - 1456	$62
AL3	1455	1456 - 1464	$1,488

DAMAGE BREAKDOWN

AL1: Lake Elevation 1447					AL2: Lake Elevation 1450					AL3: Lake Elevation 1455				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Sewage Treatment Lagoon	1	EA	$159,000	$159	House	1	EA	$62,000	$62	House	24	EA	$62,000	$1,488
Total				**$159**	**Total**				**$62**	**Total**				**$1,488**

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.

Table 2.5-2

Flood Protection Costs

Feature 5: St. Michael

Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Action Level	Lake Elevation	S (3) Incremental Relocation at AL1, AL2, AL3	S(1)S Incremental Relocation at AL1; Relocate All Structures at AL2	S Relocate all Structures at AL1
	(MSL)	(THOUSANDS)		
AL1	1447	$159	$159	$1,859
AL2	1450	$68	$1,700	$0
AL3	1455	$1,632	$0	$0

COST BREAKDOWN

		S(3)					S(3)					S(3)				
		S(1)S					S(1)S									
		S														
		Lake Elevation 1447					Lake Elevation 1450					Lake Elevation 1455				
Strategy		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Incremental Relocation																
	Move	Sewage Treatment Lagoon	1	EA	$159,000	$159	House	1	EA	$68,000	$68	House	24	EA	$68,000	$1,632
		Subtotal				$159	Subtotal				$68	Subtotal				$1,632
		Total				**$159**	**Total**				**$68**	**Total**				**$1,632**

Strategy		Lake Elevation 1447				
Maximum Protection Levee Raise*		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
	Levee	Performance/Payment B	1	JB	$26,893	$27
		Stripping	12,366	CY	$1.25	$15
		Inspection Trench	3,226	LF	$3.75	$12
		Impervious Fill	392,914	CY	$4.40	$1,729
		Bedding	22,656	CY	$35.00	$793
		Riprap	42,480	CY	$45.00	$1,912
		Sand Drain	27,870	CY	$20.00	$557
		Topsoil (4")	3,542	CY	$1.25	$4
		Seed	7	ACR	$900.00	$6
		Pump Station	1	EA	$350,000	$350
		Subtotal				$5,406
		Contingency (30%)				$1,622
		Subtotal w/ Contingency				$7,028
		Engineering and Design (6%)				$422
		Supervision and Administration (10%)				$703
		1998 Total				$8,152
		2001 Total (add inflation)				$8,270
		2001 Adjusted Total				$8,271
	Pump Station	Pump Station	1	EA	$371,000	$371
		Subtotal				$371
		Total				**$8,642**

* This maximum protection levee raise cost was not analyzed in our conceptual model due to its excessive cost.

Notes:

1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. The costs for the Relocate All Structures at AL1 strategy (S) is equal to the sum of all relocations that have not been included in incremental relocations.
4. 2001 Total for levee cost is equal to the 1998 Total cost minus the pump station cost multiplied by 6% to increase for inflation.
5. 2001 Adjusted Total adjusts detailed cost breakdown to match the 2001 totals.

Table 2.5 - 3

Economic Analysis of Strategies for St. Michael (Feature 5)

Strategy		Stochastic Analysis (ST) Mean Value over 10,000 Traces (Annual)								
		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$19,400	$19,400	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$116,300	$116,300	$0	$0	$19,400	-$97,000	0.17
S(1)S	1 Incremental Relocation: Then Relocate All Remaining	$0	$0	$40,700	$40,700	$0	$0	$19,400	-$21,400	0.48
S(3)	3 Incremental Relocations	$0	$0	$20,200	$20,200	$0	$0	$19,400	-$900	0.96

Strategy		Wet Future Scenario (WF) (Annual)								
		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$70,400	$70,400	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$116,700	$116,700	$0	$0	$70,400	-$46,300	0.60
S(1)S	1 Incremental Relocation: Then Relocate All Remaining	$0	$0	$104,300	$104,300	$0	$0	$70,400	-$33,900	0.67
S(3)	3 Incremental Relocations	$0	$0	$76,300	$76,300	$0	$0	$70,400	-$5,900	0.92

Strategy		Moderate Future 1 Scenario (M1) (Annual)								
		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$11,800	$11,800	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$116,700	$116,700	$0	$0	$11,800	-$105,000	0.10
S(1)S	1 Incremental Relocation: Then Relocate All Remaining	$0	$0	$57,800	$57,800	$0	$0	$11,800	-$46,100	0.20
S(3)	3 Incremental Relocations	$0	$0	$11,900	$11,900	$0	$0	$11,800	-$200	0.99

Strategy		Moderate Future 2 Scenario (M2) (Annual)								
		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$12,800	$12,800	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$116,700	$116,700	$0	$0	$12,800	-$103,900	0.11
S(1)S	1 Incremental Relocation: Then Relocate All Remaining	$0	$0	$88,400	$88,400	$0	$0	$12,800	-$75,500	0.14
S(3)	3 Incremental Relocations	$0	$0	$13,100	$13,100	$0	$0	$12,800	-$300	0.98

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.375% and rounded to the nearest $100.

* Total benefits are calculated as the total damages incurred for the "No Protection strategy" minus the total damages for the strategy implemented (F(S)).

Attachment to 2.5:
St. Michael Economic Analysis Assumptions

A. Levees

1. It was assumed that 7 feet of freeboard would be required for levee protection at the maximum lake level, based on the proposed freeboard for the City of Devils Lake and the high waves predicted for this area.

2. A decision was assumed to be made when the lake is 1 foot below the design level of protection (i.e., 1 foot below the lower limit of the required freeboard of a levee).

3. It was assumed that any levee constructed for the community would protect the sewage lagoons. The top of the existing sewage lagoons is at elevation 1451. The lagoons were assumed to be affected at action level 1447 because of potential wave damage.

4. For strategies that include levee protection, it was assumed that the lagoons would continue to function as the lake continues to rise. A brief analysis of groundwater in the area indicates that it would not affect the operation of lagoons in the area (*Hydrogeology of the Shallow Water Table at the City of Devils Lake, North Dakota*, North Dakota State Water Commission, 1998).

5. Construction costs for pump stations to remove interior drainage behind the levee were estimated to be $350,000. This cost is in 1998 dollars, therefore it was updated for inflation by multiplying it by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001. The updated cost is $371,000.

6. A preliminary cost estimate (1998 dollars) indicated that the cost of a levee would be approximately $8 million to protect to the maximum lake level. The cost of incremental levee raises would be $4.0 and $5.0 million at elevations 1447 and 1450, respectively. Since the cost of the levees would be far in excess of the estimated value of the structures at each action level, the levee protection strategy was not pursued further. Therefore, only relocation strategies were analyzed for St. Michael.

B. Residential and Commercial Properties

1. For relocation strategies, a decision was assumed to be made when the lake is 1 foot below the level of the low structure. This was based on the existing process which is influenced by the availability of movers, the estimated lake rise each spring, and the restrictions of funding programs. Depending on the slope of the land, wave action may affect structures several feet above the lake's level.

2. The average value of a house in St. Michael was estimated to be $62,000. This figure was obtained from the Federal Emergency Management Agency (FEMA) and represents the average value of a house located on the Spirit Lake Nation Reservation. The value for each house was determined for FEMA by certified flood insurance adjusters and was based on total habitable square footage of the

buildings and standardized real estate appraisals (*FEMA*, personal communication, March, 2001). These values did not include the value of land on which the houses were located.

3. Relocation costs for homes were estimated to be $68,000. This cost was obtained from the North Dakota-North Central Planning Council and represents the average cost to relocate a residence during the buyout program conducted in Churchs Ferry (2000). The $68,000 includes the following costs: demolition of the existing house, purchase of an equivalent house in a nearby community, purchase of a lot, and legal, appraisal, and management fees. It was assumed relocation costs would be the approximately the same in St. Michael as they were in Churchs Ferry.

4. The cost for relocation/rebuilding of commercial and public facilities was assumed to be 100% of the value of the structure and property.

5. For relocation strategies, the advanced replacement of the lagoon was estimated at $150,000 (*Devils Lake Spirit Lake Nation Reservation Alternatives Assessment*, Barr Engineering Company, October, 1997). This cost is in 1998 dollars, therefore it was updated for inflation by multiplying it by the ENR Construction Cost Index of 1.06. The updated cost is $159,000.

2.6 Summary of Economic Analysis Investigation for Feature 6: Gilbert C. Grafton Military Reservation

2.6.0 Flood Protection Strategy

The flood protection strategy that was analyzed for Gilbert C. Grafton Military Reservation (Camp Grafton) in the Economic Analysis of Devils Lake Alternatives was to provide shoreline and levee protection for Avenue A, levee protection for the munitions training facility, and raise the main access road to the camp.

2.6.1 General Information

Feature Type: State Facility

Location: Gilbert C. Grafton Military Reservation is located approximately 6 miles south southwest of the City of Devils Lake along the west side of ND Highway 20. The accompanying Figure 2.6-1 shows the feature's location and approximate extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: Gilbert C. Grafton Military Reservation is the main training site for the North Dakota Army National Guard. It is a 1,600-acre camp, accommodating up to 3,000 soldiers with housing, dining hall facilities, field, and classroom training facilities. This main camp facility is also associated with the 10,000 acre Camp Grafton South training area, located 35 miles to the south.

Significance: Camp Grafton is important because it is the major training facility for the North Dakota Army National Guard, and its operation has a major economic impact on the community

Damages: The flooding of Camp Grafton would result in the following damages:

- loss of access to this important training facility
- loss of training facilities
- loss of commerce associated with Camp operation, visitors

Owner/Sponsor: The North Dakota Army National Guard is responsible for managing and maintaining Camp Grafton.

Lead Federal Agency: The State of North Dakota would take the lead for Camp Grafton for any flood protection work that may take place. It is unlikely that federal agency involvement would be necessary.

2.6.2 Feature Protection

History of Flood Protection: In the past, flood protection for Camp Grafton has generally consisted of access road raises. The camp pumps seepage water from several low areas west of ND Highway 20 to maintain a portion of their training facilities. The sewer system has been converted to Ramsey County Rural Utility Service.

General Protection Strategy: The Economic Analysis identified and evaluated a combination approach for protecting Camp Grafton. This approach assumed:

- ND Highway 20 is assumed to be raised to provide access to the camp
- Camp Grafton will not close, even if water surfaces reach maximum level, because a significant portion of the facility property is above Elevation 1475
- The main gate is the only gate that will be maintained and raised
- Buildings will not be moved
- A levee will be constructed to protect the munitions storage area
- Riprap will be installed to protect the lakeward side of Avenue A

Protection Strategy by Lake Level: The Economic Analysis of Devils Lake Alternatives considered various protection strategies, with flood protection decisions being made at various lake levels as Devils Lake continued to rise. Figure 2.6-2 shows the decision tree for Gilbert C. Grafton Military Reservation. As shown on Figure 2.6-2, the stepwise approach to flood protection for Gilbert C. Grafton Military Reservation that was analyzed consisted of the following:

1. At lake elevation 1447, the munitions facility levee would be constructed and the access road would be raised to 1452.5.
2. At lake elevation 1451.5, the munitions facility levee and access road would be raised to 1457.5.
3. At lake elevation 1456.5, the munitions facility levee and access road would be raised to 1462.5.
4. At lake elevation 1461.5, the munitions facility levee and access road would be raised to 1468.

The maximum protection strategy that was analyzed at the first action level was raising the access road and constructing the levees to 1468. (Note that for the analysis, the decision regarding whether or not to raise the road is made at a time when the lake is one foot below the minimum access road elevation that resulted from the most recent raise.)

Interdependencies: The protection of Camp Grafton is related to the protection of ND Highway 20. Without a road raise on ND Highway 20, there is no access to Camp Grafton at the main entrance.

Table 2.0-1, mentioned earlier in this report, provides a summary of the interdependencies among the features.

2.6.3 Feature Economics

Damages: For Camp Grafton, the damages resulting from flooding were estimated up to the maximum lake level (1463). The damage computations for Camp Grafton are summarized in the accompanying Table 2.6–1.

The first portion of the table shows the damages that are associated with each action level (1447, 1451.5, 1456.5, and 1461.5), each representing damages within a range of lake levels. The second portion of the table is a breakdown of damages to buildings that would be inundated by rising waters. These damages are based on capitalized values of the buildings impacted, as provided by camp operations staff. Inundated land values are also listed, using a standard assessed value per acre.

Unit costs for all the damage computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for Gilbert C. Grafton Military Reservation are listed in the Feature 6 Assumptions listing, appended to this Section 2.6.

Costs: The costs of providing flood protection for Camp Grafton are detailed in the accompanying Table 2.6-2. Unit costs, data sources, and relevant assumptions are listed. The first portion of the table shows the cost of each strategy for each action level (1447, 1451.5, 1456.5, and 1461.5).

Protection strategies consisted of:

- Main access road raise
- Munitions area levee raise
- Avenue A slope protection

The second portion of the table is a breakdown of the costs for raising the camp entrance road, constructing a levee to protect the munitions storage facility, and installing riprap and levees along Avenue A. Road raise costs are broken down into fabric liner, fill, and riprap. Levee construction is broken down into impervious fill, bedding, riprap, sand drain, topsoil, seed, and pump station costs. Riprap costs are divided into bedding and riprap costs.

Unit costs for all the cost computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for Camp Grafton are listed in the Feature 6 Assumptions listing, appended to this Section 2.6.

2.6.4 Results of Economic Analysis

The results of the Economic Analysis for Camp Grafton are listed in Table 2.6-3.

Stochastic Analysis Results: The flood protection strategy that was evaluated is incremental raises of the munitions facility levee and access road, and is highlighted on the decision tree (Figure 2.6-2). The net benefits for this strategy were less than zero (-$237,600). The BCR for this strategy was less than one (0.11). These results indicate that this strategy was not economically justified. The remaining damages to Camp Grafton land (that are currently being protected by ND Highway 20) was computed to have a present worth value of $4,700, annualized. The stochastic results are averages over 10,000 traces.

Results for Specific Scenarios: In the economic analysis, flood protection strategies were also analyzed for three specific climate futures. For Gilbert C. Grafton Military Reservation, the identified strategy and the economic indices for each of the three climate futures are as follows:

- Wet Future – For the wet future, the flood protection strategy had negative net benefits (-$562,700) and the BCR was 0.01, indicating that this strategy was not economically justified. The remaining damages to Camp Grafton land were computed to have a present worth value of $9,200, annualized.

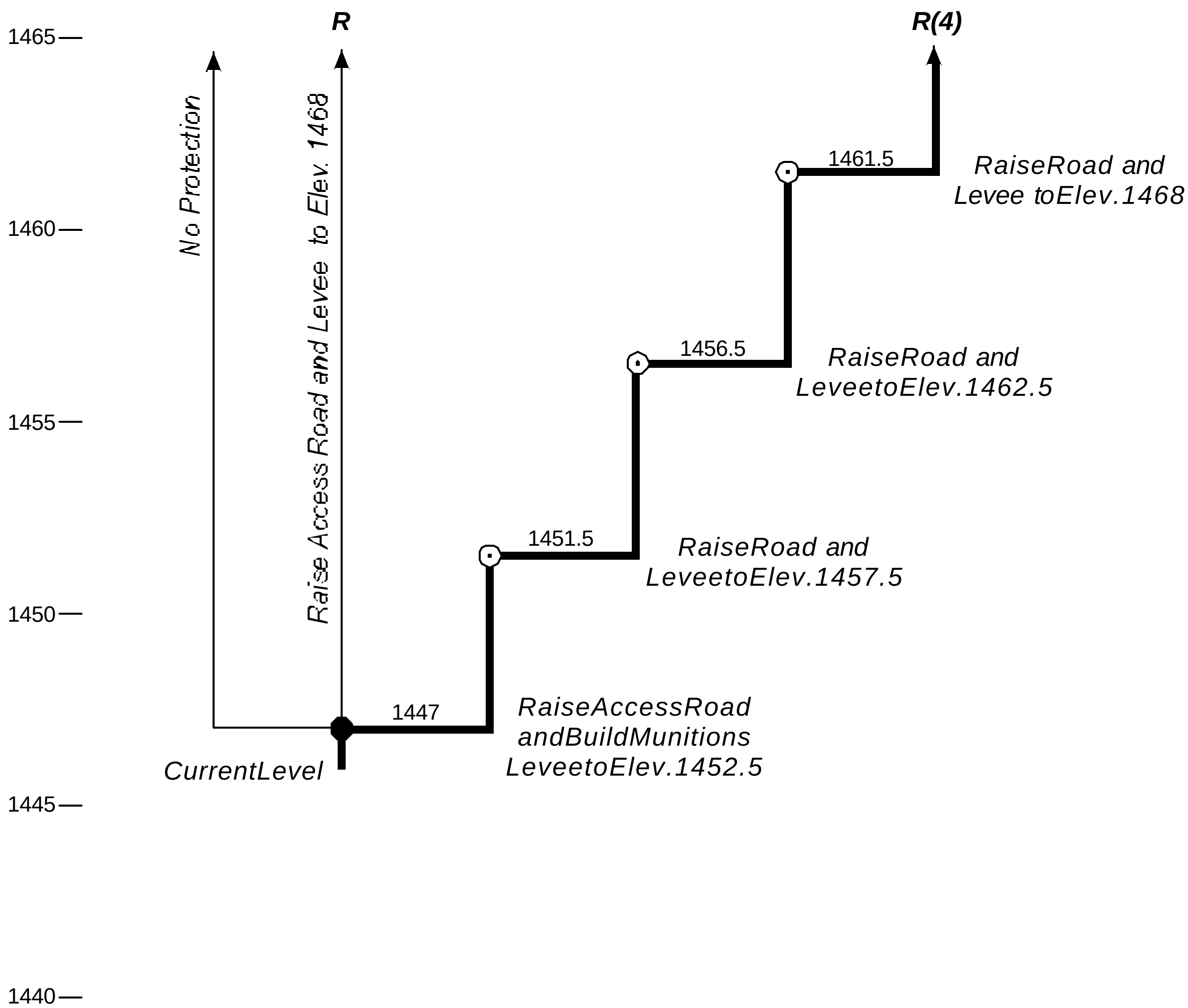
- First Moderate Future – For the first moderate future, the flood protection strategy had net benefits that were –$195,000 and the BCR was 0.01, indicating that this strategy was not economically justified. The remaining damages to Camp Grafton land were computed to have a present worth value of $3,700, annualized.

- Second Moderate Future – For the second moderate future, the flood protection strategy had net benefits that were -$288,500 and the BCR was 0.01, indicating that this strategy was not economically justified. The remaining damages to Camp Grafton land were computed to have a present worth value of $5,600, annualized.

Figure 2.6-1
LOCATION MAP
FEATURE 6: GILBERT C. GRAFTON MILITARY RESERVATION
Devils Lake Infrastructure Protection Study

Barr: Arcview 3.1, PIII,AF, I:\Client\DevilsLake\Gis\DLIP Features\StateRuralFeatures\06_Grafton\Project\basemap_06.apr, Layout: Section 2 Figure Camp Grafton, lkp, Wed Oct 30 16:05:09 2002

DATA: 1997 USGS Digital Ortho Quad



FloodProtectionStrategy

Decisionrequiredatthispoint

Triggerpointforaction,nodecisionneeded

R(1) Incrementalroad raise(numberoftimes)

R Raiseroadtoelev.1468

Figure2.6-2

DECISION TREE
FEATURE6:GILBERTC. GRAFTON
MILITARY RESERVATION
DevilsLakeInfrastructure ProtectionStudy

Table 2.6-1

Flood Damages

Feature 6: Gilbert C. Grafton Military Reservation

Devils Lake Infrastructure Protection Study

DAMAGES

Action Level	Lake Elevation	Structure Elevation Range	Structures and Infrastructure	Land
	(MSL)	(MSL)	(THOUSANDS)	
AL1	1447	Below 1452	$45	$58
AL2	1451	1452 - 1457	$0	$65
AL3	1456	1457 - 1462	$0	$65
AL4	1461	1462 - 1464	$34,732	$72

DAMAGE BREAKDOWN

AL1: Lake Elevation 1447				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure				
Munitions Area Buildings	1	EA	$45,000	$45
Includes Ammo Storage				
Office and 4 Ammo Storage				
Bunkers				
Total				**$45**
Land				
Land	147	ACR	$400	$59
2001 Adjusted Total				$58
Total				**$58**

AL2: Lake Elevation 1451				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Total				**$0**
Land	163	ACR	$400	$65
Total				**$65**

AL3: Lake Elevation 1456				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Total				**$0**
Land	163	ACR	$400	$65
Total				**$65**

AL4: Lake Elevation 1461				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Total Buildings (Les	1	EA	$25,155,000	$25,155
Camp Grafton South)				
Infrastructure	1	EA	$9,577,000	$9,577
Total				**$34,732**
Land	180	ACR	$400	$72
Total				**$72**

Notes:

1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. 2001 Adjusted Total adjusts detailed damage breakdown to match the 2001 totals.

Table 2.6-2

Flood Protection Costs

Feature 6: Gilbert C. Grafton Military Reservation

Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Action Level	Lake Elevation	R Raise Access Road and Build Munitions Levee at AL1	R(4) Raise Access Road and Build Munitions Levee at AL1, AL2, AL3, AL4
	(MSL)	(THOUSANDS)	
AL1	1447	$25,226	$3,151
AL2	1451	$0	$3,124
AL3	1456	$0	$5,958
AL4	1461	$0	$12,993

COST BREAKDOWN

R — R(4) — Lake Elevation 1447

Strategy Incremental Raise	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Road Raise	Military Entrance Road - 430' Long				
	Fabric Liner	1,511	SY	$1.25	$2
	Fill	6,849	CY	$4.50	$31
	Riprap	1,007	CY	$20.00	$20
	1998 Total				$53
	2001 Total (add inflation)				$56
Levee Raise	Performance/Paymen	1	JB	$9,634	$10
	Impervious Fill	33,600	CY	$4.40	$148
	Bedding	6,488	CY	$35.00	$227
	Riprap	12,166	CY	$45.00	$547
	Sand Drain	0	CY	$20.00	$0
	Topsoil (4")	1,510	CY	$1.25	$2
	Seed	3	ACR	$900.00	$3
	Pump Station	1	EA	########	$1,000
	Subtotal				$1,937
	Contingency (30%)				$581
	Subtotal w/ Contingency				$2,518
	Engineering and Design (6%)				$151
	Supervision and Administration (10%)				$252
	1998 Total				$2,920
	2001 Total (add inflation)				$3,096
	2001 Adjusted Total				$3,095
Avenue A Riprap/Levee Raise					
	Total				**$3,151**

R — R(4) — Lake Elevation 1451

Strategy Incremental Raise	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Road Raise	Military Entrance Road - 690' Long				
	Fabric Liner	2,424	SY	$1.25	$3
	Fill	14,820	CY	$4.50	$67
	Riprap	1,616	CY	$20.00	$32
	1998 Total				$102
	2001 Total (add inflation)				$108
Levee Raise	Performance/Paymen	1	JB	$8,377	$8
	Impervious Fill	86,000	CY	$4.40	$378
	Bedding	10,814	CY	$35.00	$378
	Riprap	20,275	CY	$45.00	$912
	Sand Drain	0	CY	$20.00	$0
	Topsoil (4")	2,072	CY	$1.25	$3
	Seed	4	ACR	$900.00	$4
	Pump Station	0	EA	$1,000,000	$0
	Subtotal				$1,684
	Contingency (30%)				$505
	Subtotal w/ Contingency				$2,189
	Engineering and Design (6%)				$131
	Supervision and Administration (10%)				$219
	1998 Total				$2,539
	2001 Total (add inflation)				$2,692
Avenue A Riprap/Levee Raise	Riprap	3,900	CY	45	$176
	Bedding	975	CY	35	$34
	Subtotal				$210
	Contingency, Engineering & Design,				$96
	Supervision & Administration (46%)				
	1998 Total				$306
	2001 Total (add inflation)				$324
	Total				**$3,124**

R — R(4) — Lake Elevation 1456

Strategy Incremental Raise	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Road Raise	Military Entrance Road - 1300' Long				
	Fabric Liner	4,568	SY	$1.25	$6
	Fill	35,146	CY	$4.50	$158
	Riprap	3,045	CY	$20.00	$61
	1998 Total				$225
	2001 Total (add inflation)				$238
	2001 Adjusted Total				$239
Levee Raise	Performance/Payment	1	JB	$16,795	$17
	Impervious Fill	160,066	CY	$4.40	$704
	Bedding	18,534	CY	$35.00	$649
	Riprap	34,751	CY	$45.00	$1,564
	Sand Drain	21,650	CY	$20.00	$433
	Topsoil (4")	3,361	CY	$1.25	$4
	Seed	6	ACR	$900.00	$5
	Pump Station	0	EA	$1,000,000	$0
	Subtotal				$3,376
	Contingency (30%)				$1,013
	Subtotal w/ Contingency				$4,389
	Engineering and Design (6%)				$263
	Supervision and Administration (10%)				$439
	1998 Total				$5,091
	2001 Total (add inflation)				$5,397
	2001 Adjusted Total				$5,395
Avenue A Riprap/Levee Raise	Riprap	3,900	CY	45	$176
	Bedding	975	CY	35	$34
	Subtotal				$210
	Contingency, Engineering & Design,				$96
	Supervision & Administration (46%)				
	1998 Total				$306
	2001 Total (add inflation)				$324
	Total				**$5,958**

R — R(4) — Lake Elevation 1461

Strategy Incremental Raise	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Road Raise	Military Entrance Road - 2600' Long				
	Fabric Liner	10,048	SY	$1.25	$13
	Fill	94,003	CY	$4.50	$423
	Riprap	6,699	CY	$20.00	$134
	1998 Total				$570
	2001 Total (add inflation)				$604
Levee Raise	Performance/Payment	1	JB	$27,145	$27
	Impervious Fill	335,966	CY	$4.40	$1,478
	Bedding	28,895	CY	$35.00	$1,011
	Riprap	54,179	CY	$45.00	$2,438
	Sand Drain	24,372	CY	$20.00	$487
	Topsoil (4")	4,709	CY	$1.25	$6
	Seed	9	ACR	$900.00	$8
	Pump Station	0	EA	$1,000,000	$0
	Subtotal				$5,456
	Contingency (30%)				$1,637
	Subtotal w/ Contingency				$7,093
	Engineering and Design (6%)				$426
	Supervision and Administration (10%)				$709
	1998 Total				$8,228
	2001 Total (add inflation)				$8,722
Avenue A Riprap/Levee Raise	Performance/Payment	1	JB	$11,413	$11
	Impervious Fill	50,633	CY	$4.40	$223
	Bedding	8,831	CY	$35.00	$309
	Riprap	16,559	CY	$45.00	$745
	Topsoil (4")	1,926	CY	$1.25	$2
	Seed	4	ACR	$900.00	$4
	Pump Station	1	EA	$1,000,000	$1,000
	Subtotal				$2,294
	Contingency (30%)				$688
	Subtotal w/ Contingency				$2,983
	Engineering and Design (6%)				$179
	Supervision and Administration (10%)				$298
	1998 Total				$3,460
	2001 Total (add inflation)				$3,668
	2001 Adjusted Total				$3,667
	Total				**$12,993**

Notes:

1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. The costs for the Relocate All Structures at AL1 strategy (S) is equal to the sum of all relocations that have not been included in incremental relocations.
4. 2001 Total for levee cost is equal to the 1998 Total cost multiplied by 6% to increase for inflation.
5. 2001 Adjusted Total adjusts detailed cost breakdown to match the 2001 totals.

Table 2.6 - 3

Economic Analysis of Strategies for
Gilbert C. Grafton State Military Reservation
(Feature 6)

Strategy		Stochastic Analysis (ST) Mean Value over 10,000 Traces (Annual)								
		COST			DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
		Road Raise	Levee & Riprap	Total	Damages	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C = A + B	D	E=D	F = E(No Protection) - E(S) *	G = F - C	I = F / C
No Protection	No Protection or Relocation	$0	$0	$0	$35,300	$35,300	$0	$0	--
R	Raise Road and Munitions Levee to 1468	$63,000	$1,515,300	$1,578,300	$4,700	$4,700	$30,500	-$1,547,800	0.02
R(4)	4 Road and Munitions Levee Raises	$6,200	$262,000	$268,200	$4,700	$4,700	$30,500	-$237,600	0.11

Strategy		Wet Future Scenario (WF) (Annual)								
		COST			DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
		Road Raise	Levee & Riprap	Total	Damages	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C = A + B	D	E=D	F = E(No Protection) - E(S) *	G = F - C	I = F / C
No Protection	No Protection or Relocation	$0	$0	$0	$12,000	$12,000	$0	$0	--
R	Raise Road and Munitions Levee to 1468	$63,200	$1,520,700	$1,583,800	$9,200	$9,200	$2,800	-$1,581,000	0.00
R(4)	4 Road and Munitions Levee Raises	$17,400	$548,100	$565,500	$9,200	$9,200	$2,800	-$562,700	0.00

Strategy		Moderate Future 1 Scenario (M1) (Annual)								
		COST			DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
		Road Raise	Levee & Riprap	Total	Damages	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C = A + B	D	E=D	F = E(No Protection) - E(S) *	G = F - C	I = F / C
No Protection	No Protection or Relocation	$0	$0	$0	$6,500	$6,500	$0	$0	--
R	Raise Road and Munitions Levee to 1468	$63,200	$1,520,700	$1,583,800	$3,700	$3,700	$2,800	-$1,581,000	0.00
R(4)	4 Road and Munitions Levee Raises	$3,500	$194,400	$197,800	$3,700	$3,700	$2,800	-$195,000	0.01

Strategy		Moderate Future 2 Scenario (M2) (Annual)								
		COST			DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
		Road Raise	Levee & Riprap	Total	Damages	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C = A + B	D	E=D	F = E(No Protection) - E(S) *	G = F - C	I = F / C
No Protection	No Protection or Relocation	$0	$0	$0	$8,400	$8,400	$0	$0	--
R	Raise Road and Munitions Levee to 1468	$63,200	$1,520,700	$1,583,800	$5,600	$5,600	$2,800	-$1,581,000	0.00
R(4)	4 Road and Munitions Levee Raises	$6,700	$284,500	$291,300	$5,600	$5,600	$2,800	-$288,500	0.01

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.375% and rounded to the nearest $100.
* Total benefits are calculated as the total damages incurred for "No Protection strategy" minus the total damages for the strategy implemented (E(S)).

Attachment to 2.6:
Gilbert C. Grafton State Military Reservation Economic Analysis Assumptions

A. General Assumptions

1. It was assumed that ND Highway 20 access would be kept open to provide access to the Camp roads. These costs are not included in this feature and are analyzed separately in Feature 21: ND Highway 20 (City of Devils Lake Levee to ND Highway 57).

2. Camp Grafton is valued at approximately $35 million, not including land. These capitalized costs were provided by Captain Clark Johnson, Civil Engineer, Camp Grafton.

3. It was assumed that during high water conditions, the main gate (Gate #6 with access from Highway 20) would be the only access route that would be maintained and raised (based on conversations with Captain Clark Johnson).

4. It was assumed that the Camp would not close, even if the lake reaches its maximum level. A significant portion of the land area and all of the structures are above elevation 1463. Camp Grafton South (30 miles south) would be unaffected and could be used for maneuvers and activities that require a larger area.

5. It was assumed that the sewer system would be fully converted to the Ramsey County Rural Sewer system before lagoons were inundated (State Flood Coordination Center, Staff meeting, November 18, 1997).

6. There are currently no open culverts located under Highway 20 near Camp Grafton, and the area west of ND Highway 20 has been kept dry in recent years with pumping. It was assumed that culverts would be installed under ND Highway 20 to relieve pressure, resulting in flooding of the low areas west of ND Highway 20. It was assumed this would occur at the first action level (elevation 1447) and, thereafter, all lands west of ND Highway 20 would be inundated by lake levels higher than the elevations of those lands.

B. Levees and Roads

1. The maximum road and levee elevation was assumed to be elevation 1468, assuming a 5-foot freeboard above the maximum lake level of 1463.

2. Roads were assumed to be raised when the water surface elevation is within 1 foot of the lowpoint of the road.

3. It was assumed that a levee would be constructed to protect the munitions storage area from flooding (based on conversations with Captain Clark Johnson, Civil Engineer, Camp Grafton).

4. Riprap protection was assumed to be required to protect the lakeward side of Avenue A (conversation with Captain Clark Johnson, Civil Engineer, Camp Grafton). It was assumed that the riprap would extend from elevation 1452.5 to 1461 (based on the May 1997 3-foot contour map) and would be 2 feet thick.

5. It was assumed that a dike would be constructed along Avenue A if the water surface reached an elevation of 1461.5 to protect against wave action.

C. Structures

1. Buildings were not assumed to be moved, because most buildings are above elevation 1464 (based on conversations with Lieutenant Colonel Gary Doll, Camp Grafton).

2. Building values were based on the capitalized cost, which was computed as the original cost plus improvements. This is probably a low estimate, as some buildings were constructed in the 1940s and the replacement value would be much higher (based on conversations with Captain Clark Johnson, Civil Engineer, Camp Grafton).

3. The land value for Camp Grafton is estimated to be $400/acre. This value was provided by the Corps of Engineers (personal communication, April, 2001) and is an estimate of the average value of all land surrounding Devils Lake.

2.7 Summary of Economic Analysis Investigation for Feature 7: Grahams Island State Park

2.7.0 Flood Protection Strategy

The flood protection strategy that was analyzed in the Economic Analysis of Devils Lake Alternatives for Grahams Island State Park (Grahams Island) was to raise the access road and relocate impacted structures and facilities.

2.7.1 General Information

Feature Type: State Facility

Location: Grahams Island State Park is located 10 miles west of the City of Devils Lake, 5 miles south of ND Highway 19 along the border between Benson and Ramsey counties. The accompanying Figure 2.7-1 shows the feature's location and approximate extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: Grahams Island State Park is the largest and most developed state park facility on Devils Lake, with campground, beach, harbor, ranger and manager facilities, activity center, and trails. The campground covers 1,100 acres, and has space for 100 campers, as well as 4 sleeping cabins. The park has potable water and sewer lines, with an on-site treatment facility. All other structures and land that are located on Grahams Island were included in Feature 8.1, Rural Areas.

Significance: Grahams Island State Park is important because it is considered a major tourist attraction in the area. It is the largest and most used state park facility around Devils Lake. Park staff estimate that a total of 72,800 visitors used the park in 1995. Access to the park is affected by rising water levels; the Park was closed in 1997 when the access road was under water. During 1997, approximately $2.2 million was invested in raising the access road to the park. In 1999, the Park had 73,770 visitors.

Damages: The flooding of Grahams Island would result in the following damages:

- Loss to utility infrastructure
- Loss of residential buildings
- Loss of recreational buildings and facilities
- Loss of facility access
- Loss of user fees
- Loss of usable land

Owner/Sponsor: The North Dakota Parks and Recreation Department, is responsible for operating and maintaining the Grahams Island State Park.

Lead Federal Agency: The State of North Dakota would take the lead for Feature 7 for any flood protection work that may take place. The Federal Highway Administration would take the lead for any federal involvement in road raises.

2.7.2 Feature Protection

History of Flood Protection: In the past, flood protection for Grahams Island has consisted of raising the access road to the park and relocating buildings and other facilities to higher ground.

General Protection Strategy: The Economic Analysis identified and evaluated a combination approach for protecting Grahams Island. The approach included:

- Relocation of buildings
- Relocation / replacement of comfort station and lift station
- Relocation / replacement of a picnic area
- Raise the access road

Protection Strategy by Lake Level: The Economic Analysis of Devils Lake Alternatives considered various levels of protection strategies, with flood protection decisions being made at various lake levels as Devils Lake continued to rise. Figure 2.7-2 shows the decision tree for Grahams Island State Park. As shown on Figure 2.7-2, the stepwise approach to flood protection for Grahams Island State Park that was analyzed consisted of the following:

1. At lake elevation 1447, structures below 1450.5 would be relocated.
2. At lake elevation 1449.5, a decision would be made as to whether the structures the between 1450.5 and 1455 should be relocated with the access road raised to 1455 or relocation of all structures above 1450.5 with temporary closure of the access road.
3. At lake elevation 1454, a decision would be made as to whether the structures the between 1455 and 1457.5 should be relocated with the access road raised to 1457.5 or relocation of all structures above 1455 with temporary closure of the access road.
4. At lake elevation 1456.5, a decision would be made as to whether the structures the between 1457.5 and 1462.5 should be relocated with the access road raised to 1462.5 or relocation of all structures above 1457.5 with temporary closure of the access road.

5. At lake elevation 1461.5, a decision would be made as to whether the structures the between 1462.5 and 1464 should be relocated with the access road raised to 1468 or relocation of all structures above 1462.5 with temporary closure of the access road.

The maximum protection strategy that was analyzed at the first action level was relocation of all structures on the island and raising the access road to elevation 1468. (Note that for the analysis, the relocation of structures is made at a time when the lake is one foot below the low structure elevation. The decision regarding whether or not to raise the road is made at a time when the lake is one foot below the minimum access road elevation that resulted from the most recent raise.)

Interdependencies: The protection of Grahams Island access from the north is related to protection of Feature 18, ND Highway 19. Highway 19 is necessary to maintain access to the county road that provides access to Grahams Island.

Table 2.0-1, mentioned earlier in this report, provides a summary of the interdependencies among the features.

2.7.3 Feature Economics

Damages: For Grahams Island State Park, the damages resulting from flooding were estimated up to the maximum lake level (1463). The damage computations for Grahams Island State Park are summarized in the accompanying Table 2.7–1.

The first portion of the table shows the damages that are associated with each action level (1447, 1449.5, 1454, 1456.5, and 1461.5), each representing damages within a range of lake levels. The second portion of the table is a breakdown of damages to Grahams Island facilities inundated by rising waters. These damages are based on values provided for these facilities by park staff. Inundated land values are also listed, using standard assessed value per acre.

Unit costs for all the damage computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for Grahams Island State Park are listed in the Feature 7 Assumptions Listing, appended to this Section 2.7.

Costs: The costs of providing flood protection for Grahams Island State Park are detailed in the accompanying Table 2.6-2. Unit costs, data sources, and relevant assumptions are listed.

The first portion of the table shows the cost of each strategy for each action level (1447, 1449.5, 1454, 1456.5, and 1461.5). The second portion of the table lists costs for relocating a residential structure and two associated buildings, replacing a comfort station and lift station, and road raises. Road raise costs are broken down into fabric liner, aggregate base, fill and riprap.

Unit costs for all the cost computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for Grahams Island State Park are listed in the Feature 7 Assumptions listing, appended to this Section 2.7.

2.7.4 Results of Economic Analysis

The results of the Economic Analysis for Grahams Island are listed in Table 2.7-3.

Stochastic Analysis Results: The flood protection strategy that was analyzed was incremental relocation of structures and raising the access road. This strategy is highlighted on the decision tree (Figure 2.7-2). The net benefits for this strategy were less than zero (-$46,200). The BCR for this strategy was less than one (0.64). These results indicate that this strategy was not economically justified. The present worth annual lost business damages that would be prevented by this strategy are computed at $64,700 (averaged over 10,000 traces). The remaining damages to State Park lands were computed to have a present worth value of $11,600, annualized. The stochastic results are averages over 10,000 traces.

Results for Specific Scenarios: In the economic analysis, flood protection strategies were also analyzed for three specific climate futures. For Grahams Island State Park, the identified strategy and the economic indices for each of the three climate futures are as follows:

- Wet Future – For the wet future, the flood protection strategy had negative net benefits (-$38,400) and a BCR of 0.92, indicating that this strategy was not economically justified under this future. For this future, the present worth annualized lost business damages that would be prevented were computed at $453,200. The remaining damages to State Park lands were computed to have a present worth value of $13,300, annualized.

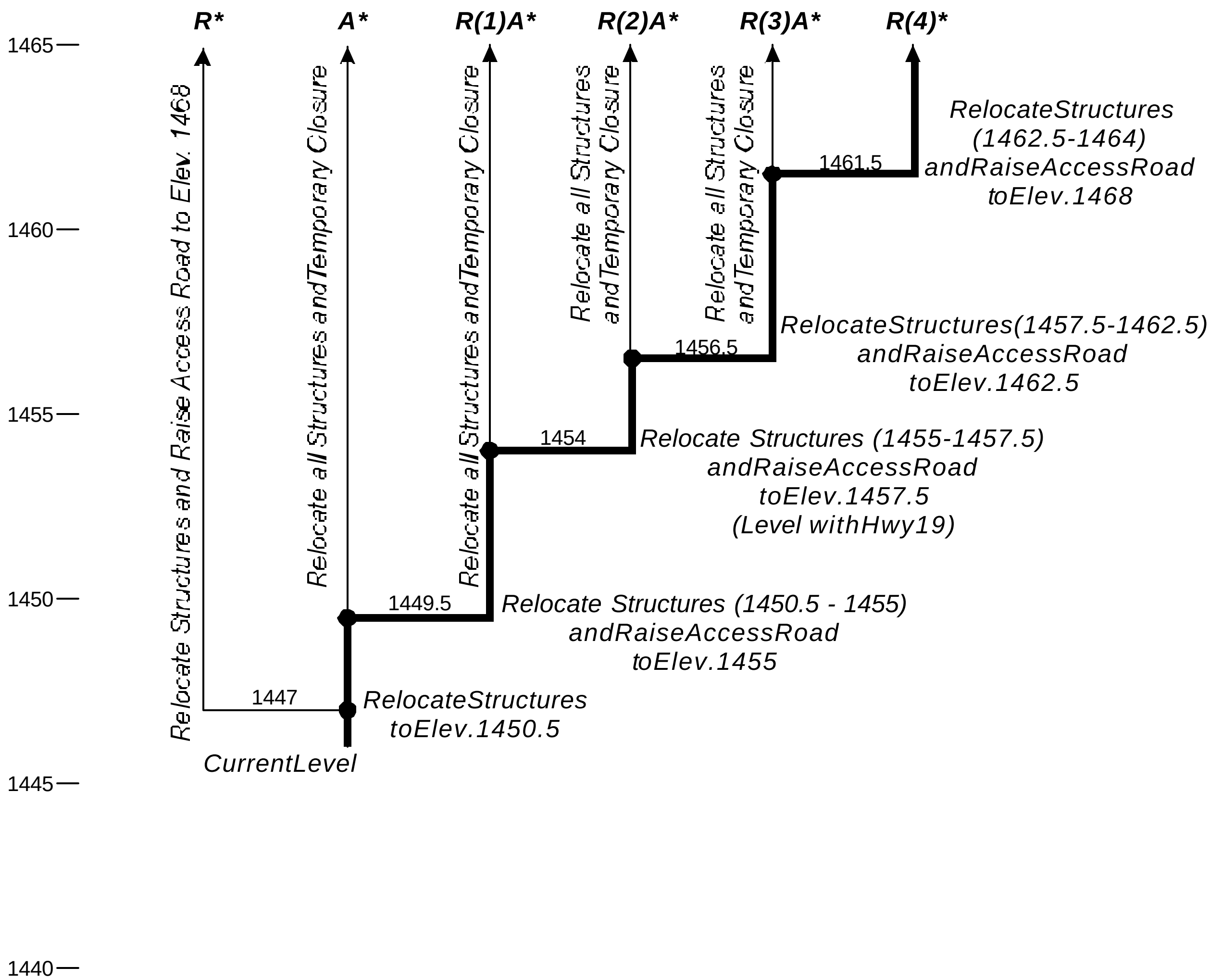
- First Moderate Future – For the first moderate future, the flood protection strategy had net benefits that were -$51,600, and the BCR was 0.52, indicating that this strategy was not economically justified under this future. For this future, the present worth annualized lost business damages that would be prevented were computed at $28,100. The remaining damages to land were computed to have a present worth value of $11,600, annualized.

- Second Moderate Future – For the second moderate future, the flood protection strategy had net benefits that were $25,600, and the BCR was 1.11, indicating that this strategy was economically justified under this future. For this future, the present worth annualized lost business damages that would be prevented were computed at $239,800. The remaining damages to land were computed to have a present worth value of $12,200, annualized.

Figure 2.7-1
LOCATION MAP
FEATURE 7: GRAHAMS ISLAND STATE PARK
Devils Lake Infrastructure Protection Study

Barr: Arcview3.3,P:\V02, I:\Client\DevilsLake\Gis\DLIP\Features\StateRuralFeatures\07_GrahamsIsland\Project\basemap_07.apr, Layout: Layout: Section 2 Grahams Island, lkp, Mon Dec 30 15:58:30 2002

DATA: 1997 USGS Digital Ortho Quad



FloodProtectionStrategy

Decisionrequiredatthispoint

Triggerpointforaction,nodecisionneeded

A Temporary closureofpark

R(1) Incrementalroad raise(numberoftimes)

***** Inadditiontoroadraisesortemporaryclosure therearealsostructurerelocations

Figure2.7-2

DECISION TREE
FEATURE 7:GRAHAMSISLANDSTATEPARK
DevilsLakeInfrastructure ProtectionStudy

P:3436\20\DECISIONTREES\2012FIGURES\FIGURE2_07.CDR RLG 01-02-03

Table 2.7-1

Flood Damages
Feature 7: Grahams Island State Park
Devils Lake Infrastructure Protection Study

DAMAGES

Action Level	Lake Elevation	Structure Elevation Range	Structures and Infrastructure	Land	Annual Damages
	(MSL)	(MSL)	(THOUSANDS)		
AL1	1447	Below 1450	$75	$157	$516
AL2	1449	1450 - 1455	$255	$19	$516
AL3	1454	1455 - 1457	$0	$11	$516
AL4	1456	1457 - 1462	$0	$21	$516
AL5	1461	1462 - 1464	$15	$23	$516

DAMAGE BREAKDOWN

AL1: Lake Elevation 1447

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure				
South Employee Residenc	1	EA	$75,000	$75
Total				**$75**
Land				
Land	393	ACR	$400	$157
Total				**$157**
Annual Damages				
Revenue	1	LS	$516,000	$516
Total				**$516**

AL2: Lake Elevation 1449

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Loop A Comfort Station	1	EA	$110,000	$110
Loop A Lift Station	1	EA	$30,000	$30
South Residence Barn	1	EA	$100,000	$100
South Residence Garage	1	EA	$15,000	$15
Total				**$255**
Land	48	ACR	400	$19
Total				**$19**
Annual Damages				
Revenue	1	LS	$516,000	$516
Total				**$516**

AL3: Lake Elevation 1454

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Land	28	ACR	$400	$11
Total				**$11**
Annual Damages				
Revenue	1	LS	$516,000	$516
Total				**$516**

AL4: Lake Elevation 1456

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Land	53	ACR	$400	$21
Total				**$21**
Annual Damages				
Revenue	1	LS	$516,000	$516
Total				**$516**

AL5: Lake Elevation 1461

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Picnic Shelter West	1	EA	$15,000	$15
Total				**$15**
Land	58	ACR	$400	$23
Total				**$23**
Annual Damages				
Revenue	1	LS	$516,000	$516
Total				**$516**

Restoration Damages

Elevation	Restoration Damages (THOUSANDS)	Excavation Quantity	Units	Unit Cost	Value (THOUSANDS)	Fabric Liner Quantity	Units	Unit Cost	Value (THOUSANDS)	Aggregate Base Course Quantity	Units	Unit Cost	Value HOUSAND	Fill Quantity	Units	Unit Cost	Cost (THOUSANDS)
1446	$0																
1447	$0																
1448	$0																
1449	$0																
1449.6	$794	59,675	CY	$2.65	$158	106,563	SY	$1.33	$141	12,788	CY	$21.20	$271	46,888	CY	$4.77	$224
1450	$794	59,675	CY	$2.65	$158	106,563	SY	$1.33	$141	12,788	CY	$21.20	$271	46,888	CY	$4.77	$224
1451	$794	59,675	CY	$2.65	$158	106,563	SY	$1.33	$141	12,788	CY	$21.20	$271	46,888	CY	$4.77	$224
1452	$794	59,675	CY	$2.65	$158	106,563	SY	$1.33	$141	12,788	CY	$21.20	$271	46,888	CY	$4.77	$224
1453	$794	59,675	CY	$2.65	$158	106,563	SY	$1.33	$141	12,788	CY	$21.20	$271	46,888	CY	$4.77	$224
1454	$794	59,675	CY	$2.65	$158	106,563	SY	$1.33	$141	12,788	CY	$21.20	$271	46,888	CY	$4.77	$224
1455	$794	59,675	CY	$2.65	$158	106,563	SY	$1.33	$141	12,788	CY	$21.20	$271	46,888	CY	$4.77	$224
1455.1	$1,013	76,102	CY	$2.65	$202	135,897	SY	$1.33	$180	16,308	CY	$21.20	$346	59,795	CY	$4.77	$285
1456	$1,013	76,102	CY	$2.65	$202	135,897	SY	$1.33	$180	16,308	CY	$21.20	$346	59,795	CY	$4.77	$285
1457	$1,013	76,102	CY	$2.65	$202	135,897	SY	$1.33	$180	16,308	CY	$21.20	$346	59,795	CY	$4.77	$285
1458	$1,013	76,102	CY	$2.65	$202	135,897	SY	$1.33	$180	16,308	CY	$21.20	$346	59,795	CY	$4.77	$285
1459	$1,013	76,102	CY	$2.65	$202	135,897	SY	$1.33	$180	16,308	CY	$21.20	$346	59,795	CY	$4.77	$285
1460	$1,013	76,102	CY	$2.65	$202	135,897	SY	$1.33	$180	16,308	CY	$21.20	$346	59,795	CY	$4.77	$285
1461	$1,013	76,102	CY	$2.65	$202	135,897	SY	$1.33	$180	16,308	CY	$21.20	$346	59,795	CY	$4.77	$285
1462	$1,013	76,102	CY	$2.65	$202	135,897	SY	$1.33	$180	16,308	CY	$21.20	$346	59,795	CY	$4.77	$285
1463	$1,013	76,102	CY	$2.65	$202	135,897	SY	$1.33	$180	16,308	CY	$21.20	$346	59,795	CY	$4.77	$285

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.

Table 2.7-2

Flood Protection Costs
Feature 7: Grahams Island State Park
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Action Level	Lake Elevation	R* Relocate Structures and Raise Road at AL1	A* Relocate Structures at AL1; Temporary Closure of Park at AL2	R(1)A* Relocate Structures at AL1; Raise Road and Relocate Structures at AL2; Temporary Closure of Park at AL3	R(2)A* Relocate Structures at AL1; Raise Road and Relocate Structures at AL2, AL3; Temporary Closure of Park at AL4	R(3)A* Relocate Structures at AL1; Raise Road and Relocate Structures at AL2, AL3, AL4; Temporary Closure of Park at AL5	R(4)* Relocate Structures at AL1; Raise Road and Relocate Structures at AL2, AL3, AL4, AL5
	(MSL)	(THOUSANDS)					
AL1	1447	$18,002	$56	$56	$56	$56	$56
AL2	1449	$0	$0	$3,713	$3,713	$3,713	$3,713
AL3	1454	$0	$0	$0	$2,229	$2,229	$2,229
AL4	1456	$0	$0	$0	$0	$5,704	$5,704
AL5	1461	$0	$0	$0	$0	$0	$6,300

* In addition to a road raise or temporary closure there are also structure relocations.

COST BREAKDOWN

R

Lake Elevation 1447 (A, R(1)A, R(2)A, R(3)A, R(4)A)

Strategy (Incremental Relocation)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Move	South Employee Residenc	1	EA	$56,000	$56
	Subtotal				$56
Road Raise					
	Total				$56

Lake Elevation 1449 (R(1)A, R(2)A, R(3)A, R(4)A)

Strategy (Incremental Relocation)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Move	Loop A Compfort Statio	1	EA	$110,000	$110
	Loop A Lift Station	1	EA	$30,000	$30
	South Residence Barn	1	EA	$75,000	$75
	South Residence Garag	1	EA	$11,300	$11
	Subtotal				$226
Road Raise	County Road #1020				
	Fabric Liner	106,037	SY	$1.25	$133
	Aggregate Base	8,558	CY	$20.00	$171
	Fill	196,842	CY	$4.50	$886
	Riprap	70,691	CY	$20.00	$1,414
	1998 Total				$2,603
	2001 Total (add inflation)				$2,760
	County Road #1021				
	Fabric Liner	27,930	SY	$1.25	$35
	Aggregate Base	2,254	CY	$20.00	$45
	Fill	51,848	CY	$4.50	$233
	Riprap	18,620	CY	$20.00	$372
	1998 Total				$686
	2001 Total (add inflation)				$727
	Total				$3,713

Lake Elevation 1454 (R(2)A, R(3)A, R(4)A)

Strategy (Incremental Relocation)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Move					
Road Raise	County Road #838				
	Fabric Liner	33,937	SY	$1.25	$42
	Aggregate Base	3,520	CY	$20.00	$70
	Fill	41,067	CY	$4.50	$185
	Riprap	22,624	CY	$20.00	$452
	1998 Total				$750
	2001 Total (add inflation)				$795
	County Road #1020				
	Fabric Liner	29,405	SY	$1.25	$37
	Aggregate Base	0	CY	$20.00	$0
	Fill	142,639	CY	$4.50	$642
	Riprap	19,604	CY	$20.00	$392
	1998 Total				$1,071
	2001 Total (add inflation)				$1,135
	County Road #1021				
	Fabric Liner	7,745	SY	$1.25	$10
	Aggregate Base	0	CY	$20.00	$0
	Fill	37,571	CY	$4.50	$169
	Riprap	5,164	CY	$20.00	$103
	1998 Total				$282
	2001 Total (add inflation)				$299
	Total				$2,229

Lake Elevation 1456 (R(3)A, R(4)A)

Strategy (Incremental Relocation)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Move					
Road Raise	County Road #838				
	Fabric Liner	24,189	SY	$1.25	$30
	Aggregate Base	0	CY	$20.00	$0
	Fill	111,467	CY	$4.50	$502
	Riprap	16,126	CY	$20.00	$323
	1998 Total				$854
	2001 Total (add inflation)				$906
	County Road #1020				
	Fabric Liner	103,640	SY	$1.25	$130
	Aggregate Base	1,975	CY	$20.00	$40
	Fill	517,231	CY	$4.50	$2,328
	Riprap	69,093	CY	$20.00	$1,382
	1998 Total				$3,878
	2001 Total (add inflation)				$4,111
	County Road #1021				
	Fabric Liner	15,491	SY	$1.25	$19
	Aggregate Base	0	CY	$20.00	$0
	Fill	93,928	CY	$4.50	$423
	Riprap	10,327	CY	$20.00	$207
	1998 Total				$649
	2001 Total (add inflation)				$687
	Total				$5,704

Lake Elevation 1461 (R(4)A)

Strategy (Incremental Relocation)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Move	Picnic Shelter West	1	EA	$15,000	$15
	Subtotal				$15
Road Raise	County Road #838				
	Fabric Liner	26,608	SY	$1.25	$33
	Aggregate Base	0	CY	$20.00	$0
	Fill	167,787	CY	$4.50	$755
	Riprap	17,739	CY	$20.00	$355
	1998 Total				$1,143
	2001 Total (add inflation)				$1,212
	County Road #1020				
	Fabric Liner	79,622	SY	$1.25	$100
	Aggregate Base	0	CY	$20.00	$0
	Fill	617,956	CY	$4.50	$2,781
	Riprap	53,081	CY	$20.00	$1,062
	1998 Total				$3,942
	2001 Total (add inflation)				$4,178
	County Road #1021				
	Fabric Liner	17,040	SY	$1.25	$21
	Aggregate Base	0	CY	$20.00	$0
	Fill	132,250	CY	$4.50	$595
	Riprap	11,360	CY	$20.00	$227
	1998 Total				$844
	2001 Total (add inflation)				$894
	Total				$6,299
	2001 Adjusted Total				$6,300

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. 2001 Total for road raise costs are equal to the 1998 Total cost multiplied by 6% to increase for inflation.
4. 2001 Adjusted Total adjusts detailed cost breakdown to match the 2001 totals.

Table 2.7 - 3

Economic Analysis of Strategies for
Grahams Island State Park
(Feature 7)

Stochastic Analysis (ST)
Mean Value over 10,000 Traces (Annual)

Strategy		COST			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Structure Relocation	Total	Restoration	Land and Structure	Lost Business	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C = A + B	D	E	F	G = D + E + F	H = G(No Protection) - G(S)**	I = H - C	I = H / C
No Protection	Temporary Closure of Road During Floods, No Relocation of Structures	$0	$0	$0	$12,000	$17,200	$64,700	$94,000	$0	$0	--
A*	Relocation of Structure at First Action Level: Then Temporary Closure During Floods	$0	$3,500	$3,500	$12,000	$17,000	$64,700	$93,800	$200	-$3,300	0.06
R*	Relocation of All Structures and Raise Road to 1468	#########	$18,600	$1,126,300	$0	$11,600	$0	$11,600	$82,400	-$1,043,900	0.07
R(1)A*	Relocation of Structure at First and Second Action Levels:1 Road Raise: Then Temporary Closure During Flooc	$76,500	$8,500	$85,000	$3,900	$11,500	$24,500	$39,900	$54,100	-$30,900	0.64
R(2)A*	Relocation of Structure at First and Second Action Levels:2 Road Raises: Then Temporary Closure During Floc	$91,800	$8,500	$100,300	$2,600	$11,600	$13,300	$27,500	$66,600	-$33,700	0.66
R(3)A*	Relocation of Structure at First and Second Action Levels:3 Road Raises: Then Temporary Closure During Floc	$115,000	$8,500	$123,500	$500	$11,600	$1,000	$13,200	$80,800	-$42,700	0.65
R(4)*	Relocation of Structure at First, Second, and Fifth Action Levels:4 Road Raises	$120,100	$8,500	$128,500	$0	$11,600	$0	$11,600	$82,400	-$46,200	0.64

Wet Future Scenario (WF)
(Annual)

Strategy		COST			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Structure Relocation	Total	Restoration	Land and Structure	Lost Business	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C = A + B	D	E	F	G = D + E + F	H = G(No Protection) - G(S)**	I = H - C	I = H / C
No Protection	Temporary Closure of Road During Floods, No Relocation of Structures	$0	$0	$0	$0	$27,500	$453,200	$480,600	$0	$0	--
A*	Relocation of Structure at First Action Level: Then Temporary Closure During Floods	$0	$3,500	$3,500	$0	$26,200	$453,200	$479,400	$1,200	-$2,300	0.34
R*	Relocation of All Structures and Raise Road to 1468	#########	$18,600	$1,130,300	$0	$13,300	$0	$13,300	$467,300	-$663,000	0.41
R(1)A*	Relocation of Structure at First and Second Action Levels:1 Road Raise: Then Temporary Closure During Flooc	$193,500	$16,000	$209,500	$10,000	$12,600	$271,200	$293,700	$186,900	-$22,600	0.89
R(2)A*	Relocation of Structure at First and Second Action Levels:2 Road Raises: Then Temporary Closure During Floc	$284,300	$16,000	$300,300	$11,300	$13,300	$219,900	$244,500	$236,100	-$64,300	0.79
R(3)A*	Relocation of Structure at First and Second Action Levels:3 Road Raises: Then Temporary Closure During Floc	$489,600	$16,000	$505,700	$0	$13,300	$0	$13,300	$467,300	-$38,400	0.92
R(4)*	Relocation of Structure at First, Second, and Fifth Action Levels:4 Road Raises	$489,600	$16,000	$505,700	$0	$13,300	$0	$13,300	$467,300	-$38,400	0.92

Moderate Future 1 Scenario (M1)
(Annual)

Strategy		COST			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Structure Relocation	Total	Restoration	Land and Structure	Lost Business	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C = A + B	D	E	F	G = D + E + F	H = G(No Protection) - G(S)**	I = H - C	I = H / C
No Protection	Temporary Closure of Road During Floods, No Relocation of Structures	$0	$0	$0	$21,000	$18,800	$28,100	$67,900	$0	$0	--
A*	Relocation of Structure at First Action Level: Then Temporary Closure During Floods	$0	$3,500	$3,500	$21,000	$18,800	$28,100	$67,900	$0	-$3,500	0.00
R*	Relocation of All Structures and Raise Road to 1468	#########	$18,600	$1,130,300	$0	$11,600	$0	$11,600	$56,300	-$1,074,000	0.05
R(1)A*	Relocation of Structure at First and Second Action Levels:1 Road Raise: Then Temporary Closure During Flooc	$98,000	$9,900	$107,900	$0	$11,600	$0	$11,600	$56,300	-$51,600	0.52
R(2)A*	Relocation of Structure at First and Second Action Levels:2 Road Raises: Then Temporary Closure During Floc	$98,000	$9,900	$107,900	$0	$11,600	$0	$11,600	$56,300	-$51,600	0.52
R(3)A*	Relocation of Structure at First and Second Action Levels:3 Road Raises: Then Temporary Closure During Floc	$98,000	$9,900	$107,900	$0	$11,600	$0	$11,600	$56,300	-$51,600	0.52
R(4)*	Relocation of Structure at First, Second, and Fifth Action Levels:4 Road Raises	$98,000	$9,900	$107,900	$0	$11,600	$0	$11,600	$56,300	-$51,600	0.52

Moderate Future 2 Scenario (M2)
(Annual)

Strategy		COST			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Structure Relocation	Total	Restoration	Land and Structure	Lost Business	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C = A + B	D	E	F	G = D + E + F	H = G(No Protection) - G(S)**	I = H - C	I = H / C
No Protection	Temporary Closure of Road During Floods, No Relocation of Structures	$0	$0	$0	$15,400	$24,000	$239,800	$279,200	$0	$0	--
A*	Relocation of Structure at First Action Level: Then Temporary Closure During Floods	$0	$3,500	$3,500	$15,400	$23,700	$239,800	$278,900	$300	-$3,200	0.09
R*	Relocation of All Structures and Raise Road to 1468	#########	$18,600	$1,130,300	$0	$12,200	$0	$12,200	$267,000	-$863,300	0.24
R(1)A*	Relocation of Structure at First and Second Action Levels:1 Road Raise: Then Temporary Closure During Flooc	$160,800	$14,000	$174,700	$18,600	$12,200	$68,500	$99,200	$180,000	$5,300	1.03
R(2)A*	Relocation of Structure at First and Second Action Levels:2 Road Raises: Then Temporary Closure During Floc	$227,400	$14,000	$241,300	$0	$12,200	$0	$12,200	$267,000	$25,600	1.11
R(3)A*	Relocation of Structure at First and Second Action Levels:3 Road Raises: Then Temporary Closure During Floc	$227,400	$14,000	$241,300	$0	$12,200	$0	$12,200	$267,000	$25,600	1.11
R(4)*	Relocation of Structure at First, Second, and Fifth Action Levels:4 Road Raises	$227,400	$14,000	$241,300	$0	$12,200	$0	$12,200	$267,000	$25,600	1.11

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.375% and rounded to the nearest $100.
* In addition to a road raise or temporary closure, there are also structure relocations.
** Total benefits are calculated as the total damages incurred for "No Protection strategy" minus the total damages for the strategy implemented (G(S)).

Attachment to 2.7:
Grahams Island State Park Economic Analysis Assumptions

A. General Assumptions

1. Access to Grahams Island State Park is dependent on ND Highway 19 remaining open. It was assumed that ND Highway 19 access would be kept open to provide access to the park road. The costs for ND Highway 19 are not included in this feature and are analyzed separately in Feature 18: ND Highway 19. Costs for the park access road from ND Highway 19 to the park were included in the costs of protection for this feature.

B. Roads

1. For the incremental road raise strategies, it was assumed that county roads being used as park access would be raised to the same elevation as ND Highway 19, starting with the first raise at elevation 1449.5 (1 foot below the existing road elevation).

2. For the incremental road raise strategies, it was assumed that the access road would be raised when the lake level is within 1 foot of the low road elevation.

3. The estimated maximum road elevation was elevation 1468, based on a 5-foot freeboard above the maximum lake level of 1463.

4. Road raises within the park boundary were not included because roads within the park are, for the most part, above elevation 1468.

5. If the strategy includes temporary closure during flooding, restoration costs for the access road were included when the lake drops 1 foot below the lowest point on the access road.

6. If the county access road is not raised and access to the park is temporarily lost, the value lost was assumed to equal the unit day value of time lost. The unit day value of time lost was computed as $7 per day (Corps of Engineers, personal communication, March, 2001) times the average annual number of park visitors. In 1999 the park had 73,770 visitors, which is representative of a typical year (based on conversations with Dick Horner, Park Superintendent). This number was used to compute the unit day value of time lost, for a total of $516,000 per year.

C. Structures

1. It was assumed that if access was maintained to the park, structures within the park that would be affected by the lake would be moved to high ground (above elevation 1464.) Structures were assumed to be moved when the lake level was within 1 foot of the structure.

2. The estimated value of structures was full replacement value, since all structures have been built since 1989 (based on conversations with Dick Horner, Park Superintendent).

3. If the park was temporarily closed because of lack of access, buildings at elevations greater than the maximum lake level were assumed to be unaffected. The buildings are primarily used by park staff, and could be temporarily closed while access is unavailable.

4. The land value for Grahams Island State Park is estimated to be $400/acre. This value was provided by the Corps of Engineers (personal communication, April, 2001) and is an estimate of the average value of all land surrounding Devils Lake.

5. Structure relocation costs were estimated to be 75% of the structure value for residential structures (including garages, barns, etc.) and 100% for commercial structures (lift stations, comfort stations, etc.).

6. If the park was temporarily closed because of lack of access, damages to land and structures were assumed to occur as they are affected by the rising lake level.

2.8 Summary of Economic Analysis Investigation for Feature 8: Rural Areas

2.8.0 Flood Protection Strategy

The flood protection strategy that was analyzed in the Economic Analysis of Devils Lake Alternatives for Rural Areas was relocation of structures.

2.8.1 General Information

Feature Type: Rural

Location: Rural structures are located throughout Ramsey, Benson, Nelson, and Towner counties surrounding Devils Lake and Stump Lake. The accompanying Figure 2.8-1 shows the general location covered in this feature. More detailed coverage of the Rural Areas and the inundation extents at the three reference lake levels (1447, 1454, and 1463) are shown on Figures 2.8-1a through 2.8-1e.

Description: Rural Areas consists of structures adjacent to the lake, including farmsteads and farmland, residences, state and regional parks, and communities not already covered as separate features. The rural areas were divided into two areas for purposes of this analysis, based on water level: Devils Lake Rural Areas and Stump Lake Rural Areas.

Significance: Although the cost of individual infrastructure and land components in these rural areas is not high, the total impact of rising lake levels on rural areas is significant.

Damages: The flooding of Rural Areas would result in the following damages:

- loss of homes
- loss of crop and pasture land
- loss of parks and park buildings, infrastructure

Owner/Sponsor: Counties, townships, and small towns would likely be responsible for managing and maintaining these Rural Areas.

Lead Federal Agency: The Corps of Engineers would take the lead for Rural Areas for any flood protection work that may take place. Federal Emergency Management Agency (FEMA) would take the lead for relocation of structures in Rural Areas.

2.8.2 Feature Protection

History of Flood Protection: In the past, flood protection for Rural Areas has consisted of relocation of affected structures.

General Protection Strategy: The Economic Analysis identified and evaluated relocation of affected structures for protecting Rural Areas. The analysis separated the Rural Areas into two discrete areas: Devils Lake Rural Areas (Feature 8.1) and Stump Lake Rural Areas (Feature 8.2).

Protection Strategy by Lake Level (Devils Lake Rural Areas): The Economic Analysis of Devils Lake Alternatives assumed flood protection decisions would be made at various lake levels as Devils Lake continued to rise. Figure 2.8.1-2 shows the decision tree for Devils Lake Rural Areas. As shown on Figure 2.8.1-2, the stepwise approach to flood protection for Devils Lake Rural Areas that was analyzed consisted of the following:

1. At lake elevation 1446.2, structures below 1446.5 would be relocated.
2. At lake elevation 1446.5, structures between 1446.5 and 1448 would be relocated.
3. At lake elevation 1447, structures between 1448 and 1449.5 would be relocated.
4. At lake elevation 1448.5, structures between 1449.5 and 1451 would be relocated.
5. At lake elevation 1450, structures between 1451 and 1452.5 would be relocated.
6. At lake elevation 1451.5, structures between 1452.5 and 1454 would be relocated.
7. At lake elevation 1453, structures between 1454 and 1455.5 would be relocated.
8. At lake elevation 1454.5, structures between 1455.5 and 1457 would be relocated.
9. At lake elevation 1456, structures between 1457 and 1459 would be relocated.
10. At lake elevation 1458, structures between 1459 and 1461 would be relocated.
11. At lake elevation 1460, structures between 1461 and 1464 would be relocated.

The maximum protection strategy that was analyzed at the first action level was relocation of all structures below 1464. (Note that for the analysis, the relocation of structures is made at a time when the lake is one foot below the low structure elevation.)

Protection Strategy by Lake Level (Stump Lake Rural Areas): The Economic Analysis of Devils Lake Alternatives assumed that one flood protection decision would be made as Stump Lake starts to rise. Figure 2.8.2-2 shows the decision tree for Stump Lake Rural Areas. As shown on Figure 2.8.2-2, the stepwise approach to flood protection for Stump Lake Rural Areas that was analyzed consisted of the following:

1. At lake elevation 1440, structures between 1440 and 1445 would be relocated.

(Note that for the analysis, the relocation of structures is made at a time when the lake is one foot below the low structure elevation.)

Interdependencies: Although the Rural Areas are not directly interdependent with other features, the entire rural community is heavily dependent on these other features (roads for access, communities for normal daily activities, hospitals, etc). The rural community is heavily dependent on the protection of US Highway 2 and ND Highway 1.

Table 2.0-1, mentioned earlier in this report, provides a summary of the interdependencies among the features.

2.8.3 Feature Economics

Damages: For Rural Features, the damages resulting from flooding were estimated up to the maximum lake level (1463). The damage computations for Feature 8 are summarized in the accompanying Tables 2.8.1-1 (Devils Lake Rural Areas) and 2.8.2-1 (Stump Lake Rural Areas).

Tables 2.8.1-1 and 2.8.2-1 list damages to rural residential structures and land. The first portion of the table shows the damages that are associated with each action level, each representing damages within a range of lake levels.

Unit costs for all the damage computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for Rural Areas are listed in the Feature 9 Assumptions listing, appended to this Section 2.8.

Costs: The costs of providing flood protection for Rural Areas are detailed in the accompanying Tables 2.8.1-2 (Devils Lake Rural Areas) and 2.8.2-2 (Stump Lake Rural Areas). Unit costs, data sources, and relevant assumptions are listed.

Tables 2.8.1-2 and 2.8.2-2 list costs for relocating residential structures.

Unit costs for all the cost computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for Feature 8 are listed in the Rural Areas Assumptions listing, appended to this Section 2.8.

2.8.4 Results of Economic Analysis

The results for the economic analysis of Rural Areas are presented separately for Devils Lake Rural Areas and Stump Lake Rural Areas.

Devils Lake Rural Areas

The results of the Economic Analysis for Devils Lake Rural Areas are listed in Table 2.8.1-3.

Stochastic Analysis Results: The stochastic analysis indicated that the net benefits for the incremental relocation strategy of Devils Lake Rural Areas were greater than one ($177,500). The BCR was 1.19, indicating that this strategy was economically justified. This strategy is highlighted on the decision tree (Figure 2.8.1-2). The remaining damages to land were computed to have a present worth value of $1,148,200, annualized. The stochastic results are averages over 10,000 traces.

Results for Specific Scenarios: In the economic analysis, flood protection strategies were also analyzed for three specific climate futures. For Devils Lake Rural Areas, the identified strategy and the economic indices for each of the three climate futures are as follows:

- Wet Future – For the wet future, the incremental relocation strategy had net benefits that were greater than one ($369,900). The BCR was 1.21, indicating that this strategy was economically justified. The remaining damages to land were computed to have a present worth value of $3,846,600, annualized.

- First Moderate Future – For the first moderate future, the incremental relocation strategy had net benefits of $151,900, and BCR of 1.18, indicating that this strategy was economically justified. The remaining damages to land were computed to have a present worth value of $805,100, annualized.

- Second Moderate Future – For the second moderate future, the incremental relocation strategy had net benefits of $215,500, and BCR of 1.20, indicating that this strategy was economically justified. The remaining damages to land were computed to have a present worth value of $1,791,100, annualized.

Stump Lake Rural Areas

The results of the Economic Analysis for Stump Lake Rural Areas are listed in Table 2.8.2-3.

Stochastic Analysis Results: The stochastic analysis indicated that the net benefits for the incremental relocation strategy were greater than one ($1,300). The BCR was 1.43, indicating that this strategy was economically justified. This strategy is highlighted on the decision tree (Figure 2.8.2-2). The remaining damages to land were computed to have a present worth value of $120,000, annualized. The stochastic results are averages over 10,000 traces.

Results for Specific Scenarios: In the economic analysis, flood protection strategies were also analyzed for three specific climate futures. For Stump Lake Rural Areas, the identified strategy and the economic indices for each of the three climate futures are as follows:

- Wet Future – For the wet future, the incremental relocation strategy had net benefits that were greater than one ($3,500). The BCR was 1.43, indicating that this strategy was economically justified. The remaining damages to land were computed to have a present worth value of $272,300, annualized.

- First Moderate Future – For the first moderate future, lake levels do not reach the first damage levels. The remaining damages to land were computed to have a present worth value of $96,500, annualized.

- Second Moderate Future – For the second moderate future, the incremental relocation strategy had net benefits of $2,900, and BCR of 1.43, indicating that this strategy was economically justified. The remaining damages to land were computed to have a present worth value of $205,700, annualized.

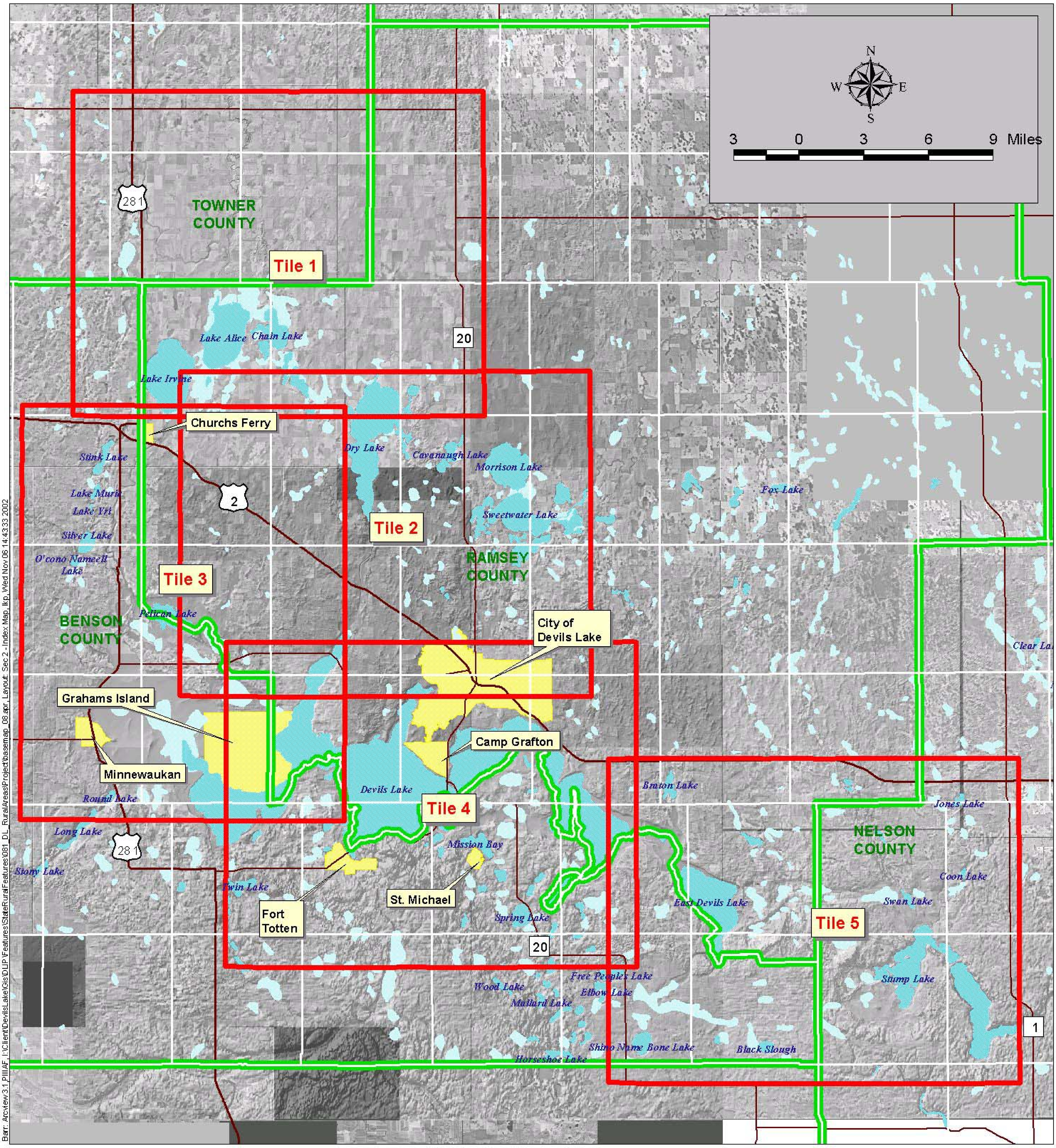


Figure 2.8-1
LOCATION MAP
FEATURE 8: RURAL FEATURES
FIGURE INDEX MAP
Devils Lake Infrastructure
Protection Study

Figure 2.8-1a

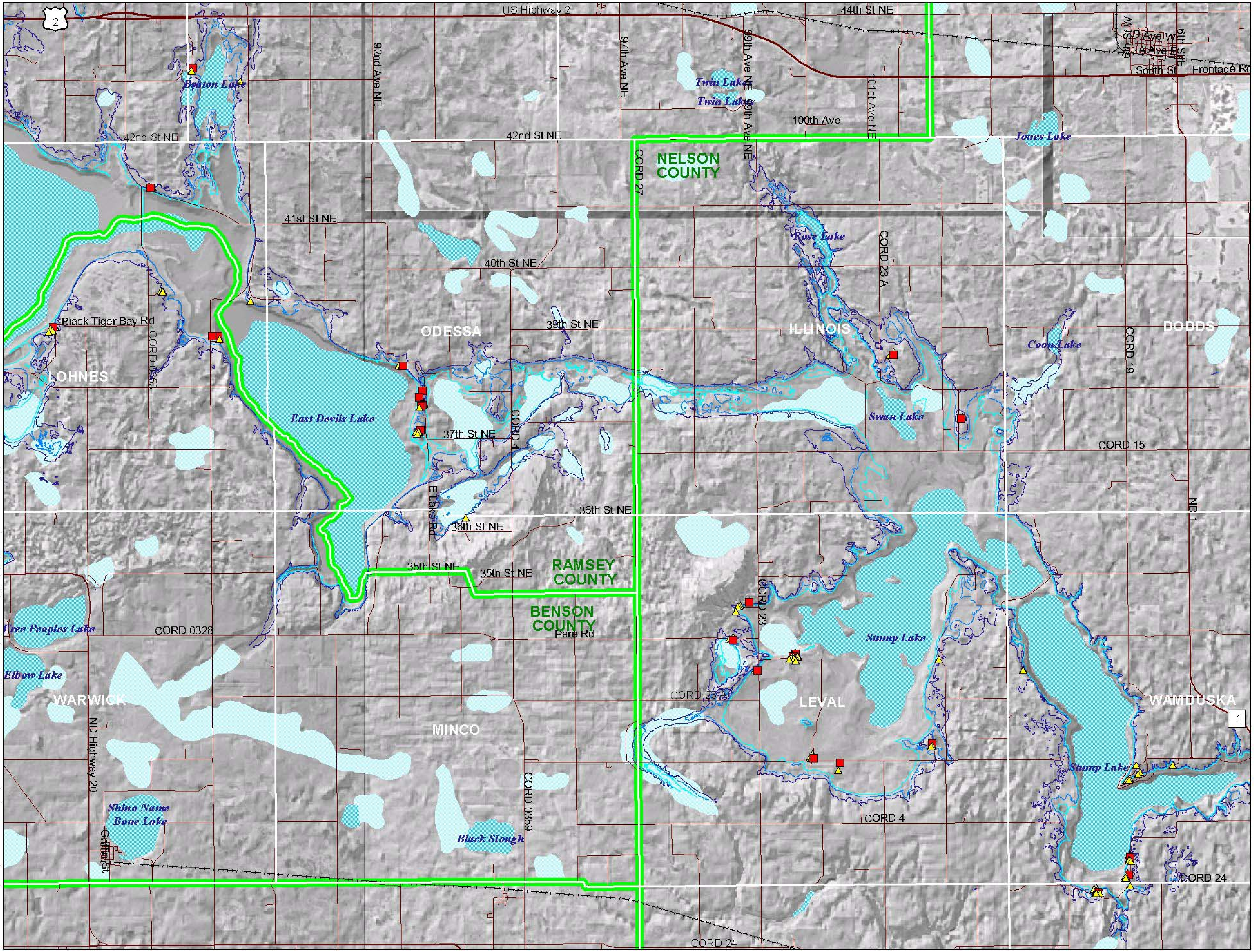
LOCATION MAP
FEATURE 8: RURAL FEATURES
(TILE 1)
Devils Lake Infrastructure
Protection Study

Figure 4.8-1b

LOCATION MAP
FEATURE 8: RURAL FEATURES
(TILE 2)
Devils Lake Infrastructure
Protection Study

Figure 2.8-1c
LOCATION MAP
FEATURE 8: RURAL FEATURES
(TILE 3)
Devils Lake Infrastructure
Protection Study

Figure 2.8-1c
LOCATION MAP
FEATURE 8: RURAL FEATURES
(TILE 3)
Devils Lake Infrastructure
Protection Study



N
W
E
S

0 0.75 1.5 2.25 3 Miles

Reference Lake Contours

1447

1454

1463

Buildings

House

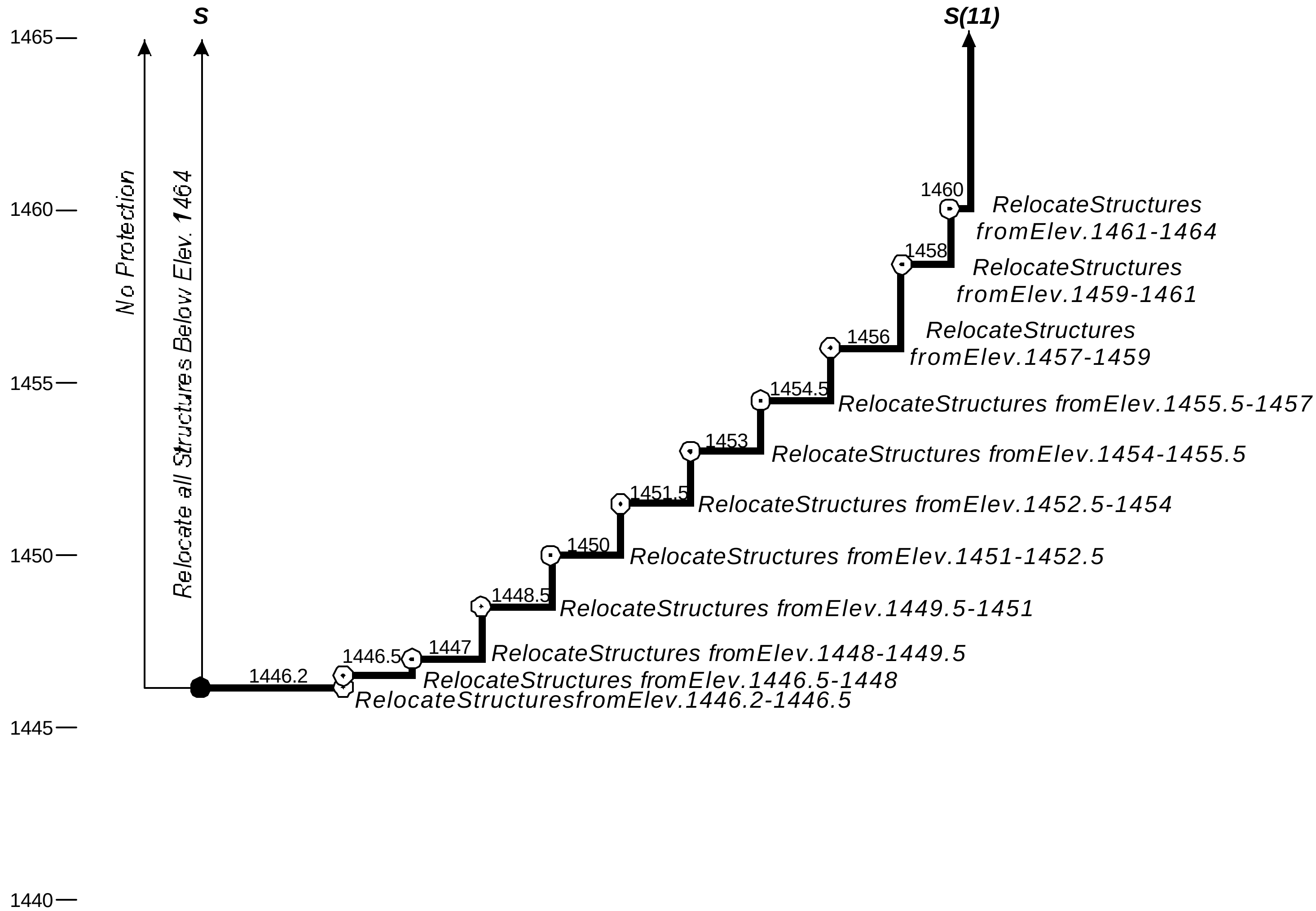
Other Buildings

Townships

Counties

Figure 2.8-1e

LOCATION MAP
FEATURE 8: RURAL FEATURES
(TILE 5)
Devils Lake Infrastructure
Protection Study



FloodProtectionStategy

Decisionrequiredatthispoint

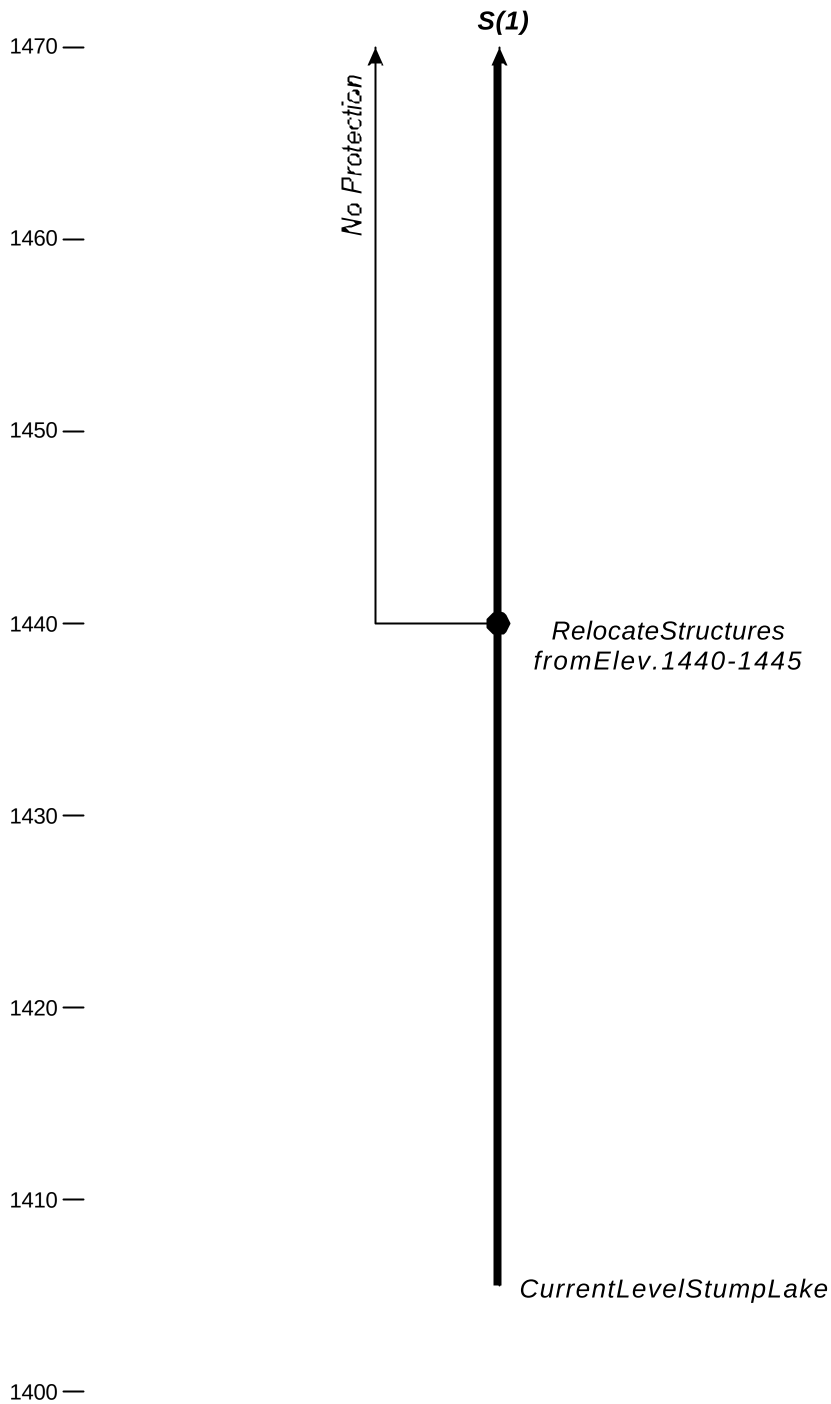
Triggerpointforaction,nodecisionneeded

S(1) Incrementalstructurerelocation(number oftimes)

S RelocateallstructuresbelowElev.1464

Figure2.8.1-2

DECISION TREE
FEATURE8.1:RURALAREAS
DevilsLakeInfrastructure ProtectionStudy



FloodProtectionStrategy

Decisionrequiredatthispoint

S(1) Incrementalstructurerelocation(number oftimes)

S RelocateallstructuresbelowElev.1464

Figure2.8.2-2

DECISION TREE
FEATURE8.2:RURALAREAS
DevilsLakeInfrastructure ProtectionStudy

Table 2.8.1-1

Flood Damages
Feature 8.1: Devils Lake Rural Areas
Devils Lake Infrastructure Protection Study

DAMAGES

Action Level	Lake Elevation	Structure Elevation Range	Structures and Infrastructure	Land
	(MSL)	(MSL)	(THOUSANDS)	
AL1	1446.2	Below 1447.5	$4,840	$0
AL2	1446.5	1447.5 - 1448	$4,446	$0
AL3	1447	1448 - 1449.5	$4,622	$4,766
AL4	1448.5	1449.5 - 1451	$2,510	$11,923
AL5	1450	1451 - 1452.5	$1,656	$6,068
AL6	1451.5	1452.5 - 1454	$2,448	$6,721
AL7	1453	1454 - 1455.5	$3,380	$7,596
AL8	1454.5	1455.5 - 1457	$2,598	$8,335
AL9	1456	1457 - 1459	$5,512	$12,564
AL10	1458	1459 - 1461	$5,134	$14,251
AL11	1460	Above 1461	$9,896	$24,268

DAMAGE BREAKDOWN

AL1: Lake Elevation 1446.2				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure				
House on Res.	2	EA	$62,000	$124
House off Res.	24	EA	$88,000	$2,112
House - Access Affected	84	EA	$31,000	$2,604
Total				**$4,840**
Land				
Land	0	ACR	$400	$0
Total				**$0**

AL2: Lake Elevation 1446.5				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure				
House on Res.	5	EA	$62,000	$310
House off Res.	47	EA	$88,000	$4,136
Total				**$4,446**
Land				
Land	0	ACR	$400	$0
Total				**$0**

AL3: Lake Elevation 1447				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure				
House on Res.	5	EA	$62,000	$310
House off Res.	49	EA	$88,000	$4,312
Total				**$4,622**
Land				
Land	11,915	ACR	$400	$4,766
Total				**$4,766**

AL4: Lake Elevation 1448.5				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure				
House on Res.	5	EA	$62,000	$310
House off Res.	25	EA	$88,000	$2,200
Total				**$2,510**
Land				
Land	29,808	ACR	$400	$11,923
Total				**$11,923**

AL5: Lake Elevation 1450				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure				
House on Res.	4	EA	$62,000	$248
House off Res.	16	EA	$88,000	$1,408
Total				**$1,656**
Land				
Land	15,170	ACR	$400	$6,068
Total				**$6,068**

AL6: Lake Elevation 1451.5				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure				
House on Res.	4	EA	$62,000	$248
House off Res.	25	EA	$88,000	$2,200
Total				**$2,448**
Land				
Land	16,803	ACR	$400	$6,721
Total				**$6,721**

AL7: Lake Elevation 1453				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure				
House on Res.	2	EA	$62,000	$124
House off Res.	37	EA	$88,000	$3,256
Total				**$3,380**
Land				
Land	18,990	ACR	$400	$7,596
Total				**$7,596**

AL8: Lake Elevation 1454.5				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure				
House on Res.	5	EA	$62,000	$310
House off Res.	26	EA	$88,000	$2,288
Total				**$2,598**
Land				
Land	0	ACR	$400	$8,335
Total				**$8,335**

AL9: Lake Elevation 1456				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure				
House on Res.	8	EA	$62,000	$496
House off Res.	57	EA	$88,000	$5,016
Total				**$5,512**
Land				
Land	31,410	ACR	$400	$12,564
Total				**$12,564**

AL10: Lake Elevation 1458				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure				
House on Res.	9	EA	$62,000	$558
House off Res.	52	EA	$88,000	$4,576
Total				**$5,134**
Land				
Land	35,628	ACR	$400	$14,251
Total				**$14,251**

AL11: Lake Elevation 1460				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure				
House on Res.	12	EA	$62,000	$744
House off Res.	104	EA	$88,000	$9,152
Total				**$9,896**
Land				
Land	60,670	ACR	$400	$24,268
Total				**$24,268**

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.

Table 2.8.1-2

Flood Protection Costs
Feature 8.1: Devils Lake Rural Areas
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Action Level	Lake Elevation	S Relocate All Structures at AL1	S(11) Relocate Structres at AL1, AL2, AL3, AL4, AL5, AL6, AL7, AL8, AL9, AL10, AL11, AL11
	(MSL)	(THOUSANDS)	
AL1	1446.2	$38,420	$4,624
AL2	1446.5	$0	$3,536
AL3	1447	$0	$3,672
AL4	1448.5	$0	$2,040
AL5	1450	$0	$1,360
AL6	1451.5	$0	$1,972
AL7	1453	$0	$2,652
AL8	1454.5	$0	$2,108
AL9	1456	$0	$4,420
AL10	1458	$0	$4,148
AL11	1460	$0	$7,888

COST BREAKDOWN

Strategy: S — Incremental Relocation — Move

S(11) — Lake Elevation 1446.2

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
House on Res.	2	EA	$68,000	$136
House off Res.	24	EA	$68,000	$1,632
House - Access Affected	84	EA	$34,000	$2,856
Total				**$4,624**

S(11) — Lake Elevation 1446.5

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
House on Res.	5	EA	$68,000	$340
House off Res.	47	EA	$68,000	$3,196
Total				**$3,536**

S(11) — Lake Elevation 1447

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
House on Res.	5	EA	$68,000	$340
House off Res.	49	EA	$68,000	$3,332
Total				**$3,672**

S(11) — Lake Elevation 1448.5

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
House on Res.	5	EA	$68,000	$340
House off Res.	25	EA	$68,000	$1,700
Total				**$2,040**

S(11) — Lake Elevation 1450

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
House on Res.	4	EA	$68,000	$272
House off Res.	16	EA	$68,000	$1,088
Total				**$1,360**

S(11) — Lake Elevation 1451.5

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
House on Res	4	EA	$68,000	$272
House off Res	25	EA	$68,000	$1,700
Total				**$1,972**

S

S(11) — Lake Elevation 1453

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
House on Res.	2	EA	$68,000	$136
House off Res.	37	EA	$68,000	$2,516
Total				**$2,652**

S(11) — Lake Elevation 1454.5

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
House on Res.	5	EA	$68,000	$340
House off Res.	26	EA	$68,000	$1,768
Total				**$2,108**

S(11) — Lake Elevation 1456

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
House on Res.	8	EA	$68,000	$544
House off Res.	57	EA	$68,000	$3,876
Total				**$4,420**

S(11) — Lake Elevation 1458

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
House on Res.	9	EA	$68,000	$612
House off Res.	52	EA	$68,000	$3,536
Total				**$4,148**

S(11) — Lake Elevation 1460

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
House on Res.	12	EA	$68,000	$816
House off Res.	104	EA	$68,000	$7,072
Total				**$7,888**

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. The costs for the Relocate All Structures at AL1 strategy (S) is equal to the sum of all relocations that have not been included in incremental relocations.

Table 2.8.1 - 3

Economic Analysis of Strategies for Devils Lake Rural Areas
(Feature 8.1)

Strategy		Stochastic Analysis (ST) Mean Value over 10,000 Traces (Annual)						
		COST		DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
		Relocation	Total	Damages	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D = C	E = D(No Protection) - D(S) *	F = E - B	I = E / A
No Protection	No Protection or Relocation	$0	$0	$2,265,900	$2,265,900	$0	$0	--
S	Relocation of All Structures below 1468	$2,412,300	$2,412,300	$1,148,200	$1,148,200	$1,117,800	-$1,294,500	0.46
S(11)	11 Incremental Relocations	$940,300	$940,300	$1,148,200	$1,148,200	$1,117,800	$177,500	1.19

Strategy		Wet Future Scenario (WF) (Annual)						
		COST		DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
		Relocation	Total	Damages	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D = C	E = D(No Protection) - D(S) *	F = E - B	I = E / A
No Protection	No Protection or Relocation	$0	$0	$5,939,900	$5,939,900	$0	$0	--
S	Relocation of All Structures below 1468	$2,412,300	$2,412,300	$3,846,600	$3,846,600	$2,093,200	-$319,000	0.87
S(11)	11 Incremental Relocations	$1,723,400	$1,723,400	$3,846,600	$3,846,600	$2,093,200	$369,900	1.21

Strategy		Moderate Future 1 Scenario (M1) (Annual)						
		COST		DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
		Relocation	Total	Damages	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D = C	E = D(No Protection) - D(S) *	F = E - B	I = E / A
No Protection	No Protection or Relocation	$0	$0	$1,795,400	$1,795,400	$0	$0	--
S	Relocation of All Structures below 1468	$2,412,300	$2,412,300	$805,100	$805,100	$990,300	-$1,421,900	0.41
S(11)	11 Incremental Relocations	$838,500	$838,500	$805,100	$805,100	$990,300	$151,900	1.18

Strategy		Moderate Future 2 Scenario (M2) (Annual)						
		COST		DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
		Relocation	Total	Damages	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D = C	E = D(No Protection) - D(S) *	F = E - B	I = E / A
No Protection	No Protection or Relocation	$0	$0	$3,103,800	$3,103,800	$0	$0	--
S	Relocation of All Structures below 1468	$2,412,300	$2,412,300	$1,791,100	$1,791,100	$1,312,600	-$1,099,600	0.54
S(11)	11 Incremental Relocations	$1,097,200	$1,097,200	$1,791,100	$1,791,100	$1,312,600	$215,500	1.20

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.375% and rounded to the nearest $100.
* Total benefits are calculated as the total damages incurred for "No Protection strategy" minus the total damages for the strategy implemented (D(S)).

Table 2.8.2-1

Flood Damages

Feature 8.2: Stump Lake Rural Areas

Devils Lake Infrastructure Protection Study

DAMAGES

Action Level	Lake Elevation	Structure Elevation Range	Structures and Infrastructure	Land
	(MSL)	(MSL)	(THOUSANDS)	
	1409	Below 1408	$0	$418
	1414	1408 - 1418	$0	$226
	1419	1418 - 1423	$0	$271
	1424	1423 - 1428	$0	$343
	1429	1428 - 1433	$0	$430
	1434	1433 - 1438	$0	$527
	1439	1438 - 1443	$0	$626
AL1	1444	1443 - 1448	$518	$1,153
	1449	1448 - 1453	$0	$807
	1454	1453 - 1458	$0	$876
	1459	Above 1458	$0	$920

DAMAGE BREAKDOWN

Lake Elevation 1409				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure				
Residences	0	LS	$0	$0
Total				**$0**
Land				
Land	1,045	ACR	$400	$418
Total				**$418**

Lake Elevation 1414				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure				
Residences	0	LS	$0	$0
Total				**$0**
Land				
Land	565	ACR	$400	$226
Total				**$226**

Lake Elevation 1419				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure				
Residences	0	LS	$0	$0
Total				**$0**
Land				
Land	678	ACR	$400	$271
Total				**$271**

Lake Elevation 1424				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure				
Residences	0	LS	$0	$0
Total				**$0**
Land				
Land	858	ACR	$400	$343
Total				**$343**

Lake Elevation 1429				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure				
Residences	0	LS	$0	$0
Total				**$0**
Land				
Land	1,075	ACR	$400	$430
Total				**$430**

Lake Elevation 1434				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure				
Residences	0	LS	$0	$0
Total				**$0**
Land				
Land	1,318	ACR	$400	$527
Total				**$527**

Lake Elevation 1439				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure				
Residences	0	LS	$0	$0
Total				**$0**
Land				
Land	1,565	ACR	$400	$626
Total				**$626**

AL1: Lake Elevation 1444				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure				
Residences	7	EA	$74,000	$518
Total				**$518**
Land				
Land	2,883	ACR	$400	$1,153
Total				**$1,153**

Lake Elevation 1449				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure				
Residences	0	LS	$0	$0
Total				**$0**
Land				
Land	2,018	ACR	$400	$807
Total				**$807**

Lake Elevation 1454				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure				
Residences	0	LS	$0	$0
Total				**$0**
Land				
Land	2,190	ACR	$400	$876
Total				**$876**

Lake Elevation 1459				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure				
Residences	0	LS	$0	$0
Total				**$0**
Land				
Land	2,300	ACR	$400	$920
Total				**$920**

Notes:

1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.

Table 2.8.2-2

Flood Protection Costs
Feature 8.2: Stump Lake Rural Areas
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Action Level	Lake Elevation	S (1) Relocate All Structures at AL1
	(MSL)	(THOUSANDS)
AL1	1444.0	$363

COST BREAKDOWN

Strategy	S(1) Lake Elevation 1446.2 Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Incremental Relocation					
Move	Residences	7	EA	$51,857	$363
	Total				**$363**

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.

Table 2.8.2 - 3

Economic Analysis of Strategies for Stump Lake Rural Areas (Feature 8.2)

Strategy		Stochastic Analysis (ST) Mean Value over 10,000 Traces (Annual)						
		COST		DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Relocation A	Total B = A	Damages C	Total D = C	To Strategy (Damages Prevented) E = D(No Protection) - D(S) *	To Strategy F = E - B	(BCR) I = E / B
No Protection	No Protection or Relocation	$0	$0	$124,200	$124,200	$0	$0	--
S(1)	Relocation of All Structures below 1468	$3,000	$3,000	$120,000	$120,000	$4,300	$1,300	1.43

Strategy		Wet Future Scenario (WF) (Annual)						
		COST		DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Relocation A	Total B = A	Damages C	Total D = C	To Strategy (Damages Prevented) E = D(No Protection) - D(S) *	To Strategy F = E - B	(BCR) I = E / B
No Protection	No Protection or Relocation	$0	$0	$283,900	$283,900	$0	$0	--
S(1)	Relocation of All Structures below 1468	$8,100	$8,100	$272,300	$272,300	$11,600	$3,500	1.43

Strategy		Moderate Future 1 Scenario (M1) (Annual)						
		COST		DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Relocation A	Total B = A	Damages C	Total D = C	To Strategy (Damages Prevented) E = D(No Protection) - D(S) *	To Strategy F = E - B	(BCR) I = E / B
No Protection	No Protection or Relocation	$0	$0	$96,500	$96,500	$0	$0	--
S(1)	Relocation of All Structures below 1468	$0	$0	$96,500	$96,500	$0	$0	--

Strategy		Moderate Future 2 Scenario (M2) (Annual)						
		COST		DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Relocation A	Total B = A	Damages C	Total D = C	To Strategy (Damages Prevented) E = D(No Protection) - D(S) *	To Strategy F = E - B	(BCR) I = E / B
No Protection	No Protection or Relocation	$0	$0	$215,300	$215,300	$0	$0	--
S(1)	Relocation of All Structures below 1468	$6,700	$6,700	$205,700	$205,700	$9,600	$2,900	1.43

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.375% and rounded to the nearest $100.

* Total benefits are calculated as the total damages incurred for "No Protection strategy" minus the total damages for the strategy implemented (D(S)).

Attachment 2.8:
Rural Areas Economic Analysis Assumptions

A. General Assumptions

1. The only viable strategy for the rural areas was to relocate residences, abandon public and private property, and relocate public utilities. The density of structures does not justify the cost for protection by a levee, and access is a potential problem if the structures were somehow protected.

2. The cost of road raises or road restoration was not considered for the rural areas in this report. Major roads in the region were analyzed as separate features, Features 13 through 24.

3. Areas that are protected by levees were not considered in the Rural Areas—these were included in the feature for the respective community or city.

4. The average value of rural houses located around Devils Lake, but not on the reservation, was $88,000. The average value for rural houses located on the Spirit Lake Nation Reservation was $62,000. These figures were obtained from the Federal Emergency Management Agency (FEMA). The average values for off-reservation and on-reservation houses were based upon 1,219 and 88 houses, respectively. The value for each house was determined for FEMA by certified flood insurance adjusters and was based on total habitable square footage of the buildings and standardized real estate appraisals. These values did not include the value of land on which the houses were located. FEMA has been using these average values for planning purposes only (*FEMA*, March, 2001). The number of houses and their elevations were also provided by FEMA. This data was used for only Feature 8.1: Devils Lake Rural Areas.

   For Feature 8.2: Stump Lake Rural Areas, the values of rural structures were assumed to be the values presented in the 1997 Depreciated Replacement Cost (*Economics Database Update for the Lands and Developments Feasibility Study, Devils Lake,* Watts & Associates, Inc., October, 1997). FEMA data was not available for the Stump Lake area. These values were updated for inflation by multiplying them by 1.09 to account for inflation of 3% per year during the period from 1998 to February 2001.

5. For Feature 8.1, within each increment it was assumed that structures would be relocated and land would be damaged when the water surface is 1 foot below the elevation of the lowest structure or land. For example, at action level 1448.5, structures between elevations 1449.5 to 1451 would be relocated and land between elevation 1449.5 to 1451 would be damaged. There are two exceptions to this for Feature 8.1: at decision/action level 1446.2, structures at elevations between 1446.2 and 1446.5 are relocated, and at decision/action level 1446.5, structures at elevations between 1446.5 and 1448 are relocated. This assumption front-end loads the costs and damages for each increment. However, wave action could affect land and structures several feet above the lake's level and, therefore, actual damages might occur well before the lake reaches the land or structure elevation.

For Feature 8.2, there are only 7 structures that are located between elevation 1445 and 1450. Therefore, all structures were assumed to be relocated at the first action/decision level of 1444. Ten additional action levels were selected for this feature to compute the damages to land. Within these elevation increments, it was assumed that land and structures would be damaged when the water surface is 1 foot below the action level, as in Feature 8.1.

6. Land value in rural areas was assumed to be $400/acre. This value was provided by the Corps of Engineers (personal communication, April, 2001) and is an estimate of the average value of all land surrounding Devils Lake.

7. The majority of Spirit Lake Nation Reservation residences are in Fort Totten and St. Michael and were considered separately in those features.

8. All structures and land in Nelson County are part of the Stump Lake watershed and would not be affected until Devils Lake overflows at elevation 1446.6. Therefore, the Stump Lake rural areas were analyzed separately from the Devils Lake rural areas. The relocation costs and damages for the Stump Lake rural areas were calculated with reference to Stump Lake water surface elevations, not Devils Lake water surface elevations.

9. All seven residences in the Nelson County portion of the study area are located between elevation 1445 and 1450 in the Stump Lake Rural Areas (*Reconnaissance Report: Devils Lake Basin, North Dakota,* St. Paul District U.S. Army Corps of Engineers, 1992).

10. In the 1998 study, costs for relocating rural utilities and damages to rural parks and boat ramps were included in the total damage values for structures and infrastructure. The total damage values were obtained from the *Economics Database Update for the Lands and Developments Feasibility Study, Devils Lake* by Watts & Associates, Inc. (October, 1997). However, relocation costs for utilities and damages to rural parks and boat ramps were not itemized in the Watts study and these data were not available elsewhere. Therefore, for the 2001 analysis these additional costs were not included in the total damages.

11. Land areas adjacent to Devils Lake and Stump Lake that would be affected by rising lake levels were obtained from the USGS (5-Box Model) elevation-volume-area relationships. Areas above elevation 1463 were extrapolated to elevation 1465.

2.9 Summary of Economic Analysis Investigation for Feature 9: Red River Valley and Western Railroad

2.9.0 Flood Protection Strategy

The Red River Valley and Western Railroad has been permanently abandoned, so this feature was not further analyzed.

2.9.1 General Information

Feature Type: Railroad

Location: Feature 9 is the portion of the Red River Valley and Western Railroad from the City of Minnewaukan extending south approximately 10 miles. The accompanying Figure 2.9-1 shows the feature's location and approximate extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: Feature 9 is a railroad. It has been permanently abandoned.

Significance: The Red River Valley and Western Railroad south from Minnewaukan has been permanently abandoned with no plans for future restoration.

Damages: The flooding of the Red River Valley Railroad would not result in any damages. No cost analyses were completed as part of the Economic Analysis of Devils Lake Alternative for this feature.

Owner/Sponsor: Red River Valley and Western Railroad.

Lead Federal Agency: Not applicable.

Figure 2.9-1
LOCATION MAP
FEATURE 9: RED RIVER VALLEY
AND WESTERN RAILROAD
Devils Lake Infrastructure
Protection Study

Barr: Arcview 3.1, P:\V02, I:\Client\DevilsLake\Gis\DLIP\Features\RoadandRails\Rails09_RRVWR\Project\basemap_09.apr, Layout: Layout: Section 2 Figure (RRVandWestern RR).lkp, Wed Oct 30 15:46:46 2002

DATA: 1997 USGS Digital Ortho Quad.

2.10 Summary of Economic Analysis Investigation for Feature 10: Canadian Pacific Railroad

2.10.0 Flood Protection Strategy

The flood protection strategy that was analyzed for Canadian Pacific Railroad in the Economic Analysis of Devils Lake Alternatives was incremental rail raises.

2.10.1 General Information

Feature Type: Railroad

Location: Feature 10 is the section of the Canadian Pacific Railroad between the City of Devils Lake and US Highway 281, approximately 18 miles. The accompanying Figure 2.10-1 shows the feature's location and approximate extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: Feature 10 is a railroad. The rail line is constructed on embankments, with approximately 3 miles near the west end of the line that is affected by the current lake level, but it is not submerged. There is a culvert under the tracks for water passage near the Mauvais Coulee and Six Mile Bay.

Significance: The tracks between the City of Devils Lake and Harlowe were predominantly used for grain shipments. This rail line has been closed since 1998. The current lake level (1447) is about 3 feet below the lowest elevation of the tracks (1450); however, wave action has caused erosion damage to the sides of the rail bed, making the railroad too dangerous to use. Grain is now trucked to a Burlington Northern Sante Fe (BNSF) line instead of being shipped by rail. Northern Plains Railroad, lessee of Canadian Pacific Railroad tracks, does not consider the railroad "abandoned" because they intend to reopen the tracks if they receive funding from the US Congress for repair and raises. Instead the railroad is considered "embargoed."

Damages: The flooding of the Canadian Pacific Railroad would result in the following damages:

- restoration cost after the lake recedes
- alternate shipping/detour damages

Owner/Sponsor: Canadian Pacific Railroad is responsible for managing and maintaining Feature 10.

Lead Federal Agency: The Corps of Engineers would take the lead for the Canadian Pacific Railroad for any raises that may take place. The Federal Railway Administration may provide funding.

2.10.2 Feature Protection

History of Flood Protection: In the past, flood protection for the Canadian Pacific Railroad between Devils Lake and Harlowe has consisted of abandoning the rail line until funding is received to raise the rail line for future use.

General Protection Strategy: The Economic Analysis of Devils Lake Alternatives analysis identified and evaluated several different approaches for protecting the Canadian Pacific Railroad. These included:

- rerouting railroad to higher ground (this strategy was dropped based on discussions with Northern Plains Railroad staff, lessee)
- raising the tracks

Protection Strategy by Lake Level: The Economic Analysis of Devils Lake Alternatives analyzed the flood protection strategy of raising the rail line, with flood-protection decisions being made at various lake levels as Devils Lake continued to rise. Figure 2.10-2 shows the decision tree for Canadian Pacific Railroad. As shown on Figure 2.10-2, the stepwise approach to flood protection for Canadian Pacific Railroad that was analyzed consisted of the following:

1. At lake elevation 1449, a decision would be made as to whether the rail line would be raised to 1455, or temporarily closed.
2. If the rail line were raised at the first action level, at lake elevation 1454, a decision would be made as to whether the rail line would be raised to 1460, or temporarily closed.
3. If the rail line were raised at the second action level, at lake elevation 1459 another decision would be made as to whether the rail line would be raised to 1468, or temporarily closed.

The maximum protection strategy that was analyzed at the first action level was raising the rail line to 1468. (Note that for the analysis, the decision regarding whether or not to raise the rail line is made at a time when the lake is one foot below the minimum rail elevation that resulted from the most recent raise.)

Interdependencies: None.

2.10.3 Feature Economics

Damages: For the Canadian Pacific Railroad, the damages resulting from flooding were estimated up to the maximum lake level (1463). The damage computations for Feature 10 are summarized in the accompanying Table 2.10–1.

Table 2.10-1 lists annual detour damages and restoration costs. Annual detour damage represents the cost for alternate shipping methods and/or routes when the rail line is closed. Restoration damages include rebuilding the rail with excavation, fill, rail material, and bridge repairs. Restoration damages are a per-event damage. They are only incurred when and if the lake recedes below the rail bed after a period of flooding. Restoration damages depend on the lake level during the period of flooding because the extent of the rail line that needs restoration depends on the extent of flooding.

Unit costs for all the damage computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for Feature 10 are listed in the Canadian Pacific Railroad Assumptions listing, appended to this Section 2.10.

Costs: The costs of providing flood protection for the Canadian Pacific Railroad are detailed in the accompanying Table 2.10-2 for the Canadian Pacific Railroad. Unit costs, data sources, and relevant assumptions are listed.

Table 2.10-2 lists unit costs of material for raising tracks and railroad bridges. Itemized costs are broken down into four categories: fill, riprap, rail, and bridge raise.

Unit costs for all the cost computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for Feature 10 are listed in the Canadian Pacific Railroad Assumptions listing, appended to this Section 2.10.

2.10.4 Results of Economic Analysis

The results of the Economic Analysis for the Canadian Pacific Railroad are listed in Table 2.10-3.

Stochastic Analysis Results: The stochastic analysis indicated that the net benefits for the flood protection strategy was less than one (-$696,700) and the BCR was 0.25, indicating that the strategy was not economically justified. This strategy is highlighted on the decision tree (Figure 2.10-2). The present worth annualized detour damages that would be prevented by this strategy were computed to be $101,400. The stochastic results are averages over 10,000 traces.

Results for Specific Scenarios: In the economic analysis, flood protection strategies were also analyzed for three specific climate futures. For Canadian Pacific Railroad, the identified strategy and the economic indices for each of the three climate futures are as follows:

- Wet Future – For the wet future, the flood protection strategy had net benefits that were less than one (-$3,161,700) and a BCR of 0.13. Therefore, the strategy was not economically justified. For this future, the present worth annualized detour damages that would be prevented were computed at $476,900.

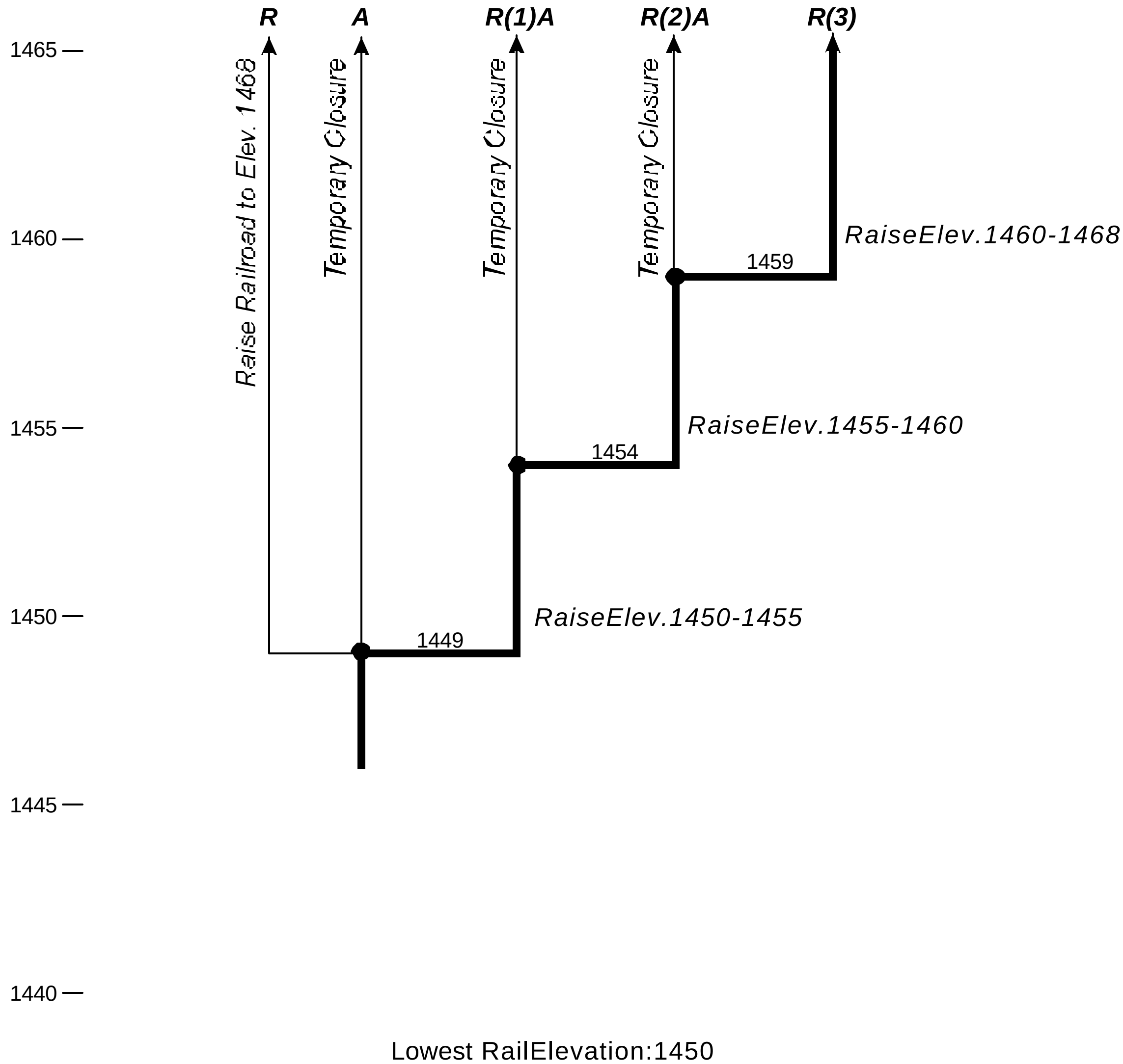
- First Moderate Future – For the first moderate future, the protection strategy had net benefits that were less than one (-$527,800) and a BCR of 0.24. Therefore, the strategy was not economically justified. For this future, the present worth annualized detour damages that would be prevented were computed to be $40,400.
- Second Moderate Future – For the second moderate future, the protection strategy had net benefits that were less than one (-$1,474,200) and a BCR of 0.22. Therefore, the strategy was not economically justified. For this future, the present worth annualized detour damages that would be prevented were computed at $245,800.

Figure 2.10-1

LOCATION MAP
FEATURE 10: CANADIAN PACIFIC RAILROAD
Devils Lake Infrastructure Protection Study

Barr: Arcview 3.1,PIIIAF, i:\client\devilslake\gis\dlip\features\roadandrails\rails10_cpr\project\basemap_10.apr, Layout: Layout: Section 2 figure, lkp, Wed Oct 30 15:32:35 2002

DATA: 1997 USGS Digital Ortho Quad.



P:3436\2010 DECISION TREES\2012 FIGURES\FIGURE2_10.CDR RLG 01-02-03

FloodProtectionStrategy

Decisionrequiredatthispoint

Triggerpointforaction,nodecisionneeded

R(1) Incrementalrailroadraise(numberoftimes)

R Railroadraiseto1468

A Temporary closureofrailroad

Figure2.10-2

DECISION TREE
FEATURE 10:CANADIANPACIFICRAILROAD
DevilsLakeInfrastructure ProtectionStudy

Table 2.10-1

Flood Damages
Feature 10: Canadian Pacific Railroad
Devils Lake Infrastructure Protection Study

DAMAGES

Action Levels	Annual Detour Damages
	(THOUSANDS)
AL1 - AL3	$509

DAMAGE BREAKDOWN

	AL1 - AL3				
Damage	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Annual Detour Damages	Candian Pacific Railroad				
	Detour Damages Quoted	1	LS	$480,000	$480
	From Railroad				
	2001 Total (add inflation)				$509
	Total				$509

Restoration Damages																	
		Excavation				Fill				Rail Material				Bridge Repair			
Elevation	Total (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)
1449	$0																
1450	$4,963	40,506	CY	$2.65	$107	40,506	CY	$9.00	$365	31,700	LF	$135	$4,280	1	EA	$212,000	$212
1451	$4,963	40,506	CY	$2.65	$107	40,506	CY	$9.00	$365	31,700	LF	$135	$4,280	1	EA	$212,000	$212
1452	$4,963	40,506	CY	$2.65	$107	40,506	CY	$9.00	$365	31,700	LF	$135	$4,280	1	EA	$212,000	$212
1453	$4,963	40,506	CY	$2.65	$107	40,506	CY	$9.00	$365	31,700	LF	$135	$4,280	1	EA	$212,000	$212
1454	$6,620	54,625	CY	$2.65	$145	54,625	CY	$9.00	$492	42,750	LF	$135	$5,771	1	EA	$212,000	$212
1455	$9,123	75,964	CY	$2.65	$201	75,964	CY	$9.00	$684	59,450	LF	$135	$8,026	1	EA	$212,000	$212
1456	$10,314	86,122	CY	$2.65	$228	86,122	CY	$9.00	$775	67,400	LF	$135	$9,099	1	EA	$212,000	$212
1457	$10,314	86,122	CY	$2.65	$228	86,122	CY	$9.00	$775	67,400	LF	$135	$9,099	1	EA	$212,000	$212
1458	$12,563	105,289	CY	$2.65	$279	105,289	CY	$9.00	$948	82,400	LF	$135	$11,124	1	EA	$212,000	$212
1459	$12,563	105,289	CY	$2.65	$279	105,289	CY	$9.00	$948	82,401	LF	$135	$11,124	1	EA	$212,000	$212
1460	$12,563	105,289	CY	$2.65	$279	105,289	CY	$9.00	$948	82,402	LF	$135	$11,124	1	EA	$212,000	$212
1461	$12,563	105,289	CY	$2.65	$279	105,289	CY	$9.00	$948	82,403	LF	$135	$11,124	1	EA	$212,000	$212
1462	$12,563	105,289	CY	$2.65	$279	105,289	CY	$9.00	$948	82,404	LF	$135	$11,125	1	EA	$212,000	$212
1463	$13,499	113,275	CY	$2.65	$300	113,275	CY	$9.00	$1,019	88,650	LF	$135	$11,968	1	EA	$212,000	$212

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. 2001 Total for annual detour damages is equal to the 1998 Total cost multiplied by 6% to increase for inflation.

Table 2.10-2

Flood Protection Costs
Feature 10: Canadian Pacific Railroac
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Action Level	Lake Elevation	R Maximum Raise at AL1	A Temporary Closure at AL1	R(1)A Raise at AL1; Temporary Closure at AL2	R(2)A Raise at AL1, AL2; Temporary Closure at AL3	R(3) Raise at AL1, AL2, AL3
	(MSL)	(THOUSANDS)				
AL1	1449	$91,146	$0	$24,597	$24,597	$24,597
AL2	1454	$0	$0	$0	$25,009	$25,009
AL3	1459	$0	$0	$0	$0	$41,540

COST BREAKDOWN

		R														
		R(1)A														
		R(2)A					R(2)A									
		R(3)					R(3)					R(3)				
		Lake Elevation 1449					Lake Elevation 1454					Lake Elevation 1459				
Strategy		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Incremental Raise																
	Rail Raise	Canadian Pacific Railroad					Canadian Pacific Railroad					Canadian Pacific Railroad				
		Fill	355,511	CY	$9.00	$3,200	Fill	841,978	CY	$9.00	$7,578	Fill	2,115,656	CY	$9.00	$19,041
		Riprap	438,643	CY	$30.00	$13,159	Riprap	470,690	CY	$30.00	$14,121	Riprap	714,781	CY	$30.00	$21,443
		Rail	59,450	LF	$135.00	$8,026	Rail	22,950	LF	$135.00	$3,098	Rail	6,250	LF	$135.00	$844
		Bridge Raise	1	EA	$212,000	$212	Bridge Raise	1	EA	$212,000	$212	Bridge Raise	1	EA	$212,000	$212
		Total				$24,597	Total				$25,009	Total				$41,540

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. The costs for the Maximum Raise at AL1 strategy (R) is equal to the sum of the costs for all incremental raises.

Table 2.10 - 3

Economic Analysis of Strategies for
Canadian Pacific Railroad: City of Devils Lake to Harlowe
(Feature 10)

Stochastic Analysis (ST)
Mean Value over 10,000 Traces (Annual)

Strategy		COSTS		DAMAGES			Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Total	Restoration	Detour	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D	E = C + D	F = E(A) - E(S) *	G = F - B	I = F / B
A	Temporary Closure During Floods at First Action Le	$0	$0	$136,200	######	$237,600	$0	$0	--
R	Rail Raise to 1468	########	########	$0	$0	$0	$237,600	-$2,230,800	0.10
R(1)A	1 Rail Raise: Then Temporary Closure During Floo	$666,200	$666,200	$49,000	$27,000	$75,900	$161,600	-$504,500	0.24
R(2)A	2 Rail Raises: Then Temporary Closure During Floo	$837,700	$837,700	$24,200	$6,300	$30,500	$207,100	-$630,600	0.25
R(3)	3 Incr. Rail Raises	$934,400	$934,400	$0	$0	$0	$237,600	-$696,700	0.25

Wet Future Scenario (WF)
(Annual)

Strategy		COSTS		DAMAGES			Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Total	Restoration	Detour	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D	E = C + D	F = E(A) - E(S) *	G = F - B	I = F / B
A	Temporary Closure During Floods at First Action Le	$0	$0	$0	######	$476,900	$0	$0	--
R	Rail Raise to 1468	########	########	$0	$0	$0	$476,900	-$4,902,900	0.09
R(1)A	1 Rail Raise: Then Temporary Closure During Floo	########	########	$158,300	######	$454,000	$22,800	-$1,429,000	0.02
R(2)A	2 Rail Raises: Then Temporary Closure During Floo	########	########	$179,000	######	$304,000	$172,800	-$2,297,700	0.07
R(3)	3 Incr. Rail Raises	########	########	$0	$0	$0	$476,900	-$3,161,700	0.13

Moderate Future 1 Scenario (M1)
(Annual)

Strategy		COSTS		DAMAGES			Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Total	Restoration	Detour	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D	E = C + D	F = E(A) - E(S) *	G = F - B	I = F / B
A	Temporary Closure During Floods at First Action Le	$0	$0	$123,300	$40,400	$163,700	$0	$0	--
R	Rail Raise to 1468	########	########	$0	$0	$0	$163,700	-$2,398,900	0.06
R(1)A	1 Rail Raise: Then Temporary Closure During Floo	$691,500	$691,500	$0	$0	$0	$163,700	-$527,800	0.24
R(2)A	2 Rail Raises: Then Temporary Closure During Floo	$691,500	$691,500	$0	$0	$0	$163,700	-$527,800	0.24
R(3)	3 Incr. Rail Raises	$691,500	$691,500	$0	$0	$0	$163,700	-$527,800	0.24

Moderate Future 2 Scenario (M2)
(Annual)

Strategy		COSTS		DAMAGES			Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Total	Restoration	Detour	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D	E = C + D	F = E(A) - E(S) *	G = F - B	I = F / B
A	Temporary Closure During Floods at First Action Le	$0	$0	$161,800	######	$407,600	$0	$0	--
R	Rail Raise to 1468	########	########	$0	$0	$0	$407,600	-$3,793,900	0.10
R(1)A	1 Rail Raise: Then Temporary Closure During Floo	########	########	$207,200	$67,500	$274,800	$132,900	-$1,001,000	0.12
R(2)A	2 Rail Raises: Then Temporary Closure During Floo	########	########	$0	$0	$0	$407,600	-$1,474,200	0.22
R(3)	3 Incr. Rail Raises	########	########	$0	$0	$0	$407,600	-$1,474,200	0.22

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.375% and rounded to the nearest $100.
* Total benefits are calculated as the total damages incurred for "temporary closure strategy" minus the total damages for the strategy implemented (E(S)).

Attachment to 2.10:
Canadian Pacific Railroad Economic Analysis Assumptions

1. Based on conversation with Greg Haug of Northern Plains Railroad, lessee of Canadian Pacific Railroad (CPR) tracks, CPR would not reroute rails to higher ground. Rerouting the track would be extremely costly. Even rebuilding a portion of the track within the railroad's right-of-way has proven to be an expensive effort. The railroad would likely raise the tracks to keep the line open as the lake level rises.

2. This railroad has been closed since 1998. The current lake level is 4 feet below the lowest elevation of the tracks (1450 MSL); however, wave action has caused erosion damage to the sides of the rail bed, making the railroad too dangerous to use. The tracks between the City of Devils Lake and Harlowe were predominantly used for grain shipments. Grain is now trucked to a BNSF line instead of being shipped by rail. This increases shipment costs by approximately $480,000 per year (based on conversations with Greg Haug – Northern Plains Railroad, lessee of CPR tracks).

3. Northern Plains Railroad does not consider the railroad "abandoned" because they intend to reopen the tracks if they receive funding from the US Congress for repair and raises. Instead the railroad is considered "embargoed." For this analysis, it was assumed that the funding will become available and the railroad will be reopened.

General Assumptions

1. Costs of railroad raises and restorations were obtained from *Devils Lake Flood Control: Economics Database Update: Transportation Report*, Barr Engineering Company, January 1998. These costs were updated for 2001 based on conversations with area railroad companies as follows:

    a. Filter fabric will no longer be placed under riprap for railroad raises; therefore, filter fabric costs were not included in the analysis.

    b. Riprap costs have increased from $20 per cubic yard to $30 per cubic yard due to inflation and scarcity of materials in the area.

    c. Fill costs have increased from $4.50 per cubic yard to $9 per cubic yard based on current costs in the area.

    d. Costs to install rails, ties and ballast were estimated at $135 per linear foot, which is representative of the cost of current installation methods in the area.

    e. Estimated railroad bridge raise costs were decreased from $500,000 per 100-foot bridge to $212,000 per 100-foot bridge based on new information on construction methods.

f. Side slopes for raises and repair of rail beds were assumed to be 2:1 instead of 3:1,based on new information on construction methods. This revised assumption was also made for the side slopes of existing rail beds.

g. Detour damages for rail abandonment were inflated to 2001 dollars.

2. It was assumed that decisions on protection would occur when the lake level is 1 foot below the top of the lowest rail bed.

3. If the railroad feature has a bridge with a low chord below the lowest rail bed, no decision will occur until the lake level is within 1 foot of the top of the lowest rail bed.

4. If railroads are temporarily closed during flooding, they were assumed to be restored when the lake recedes. Although some spur lines have been abandoned in recent years due to a loss of profitability of the lines, representatives of the respective railroads have indicated that they have no plans to abandon these specific spur lines and have indicated they would restore them if they were temporarily flooded. Burlington Northern Railroad does have a legal commitment to limit the total miles of tracks abandoned in the state, but can abandon a line if it is out of service for 2 years or more (based on a conversation with Don Laschkewitsch, Transportation Senior Manager, Railroads, NDDOT). For this study, it was assumed that the tracks would not be abandoned, but may be temporarily closed during flooding and restored when the lake recedes to 1 foot below the top of the lowest rail bed (again, with the exception of Feature 9).

Attachment to 2.11:
Burlington Northern Railroad (along US Highway 2) Economic Analysis Assumptions

1. The track along US Highway 2 is a transcontinental freight route that extends from the State of New York to the State of Washington (through the City of Devils Lake). Amtrak passenger routes use the track and many other companies use the track for shipping a variety of products across the country. Burlington Northern and Sante Fe Railway Company (BNSF) has no plans to temporarily close this line because it would affect so many train routes (conversation with Cliff Inman, BNSF). During rapid rises in the lake level, this line might experience inadvertent closure(s) due to wave action damages or subbase failure from long-term submergence of the rail bed. As with CPR, rerouting the BNSF tracks is not considered a feasible option. Therefore, rerouting tracks was not considered as a strategy in this study. Consequently, the only protection strategy evaluated for this feature is rail raises. For the no protection strategy, detour damages were estimated based on assumptions described in the following paragraphs (a – m). **These detour damages were estimated in 1998, therefore they were updated for inflation by multiplying them by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001. The 1998 assumptions are as follows:**

    a. In general, the train traffic that runs through Devils Lake along US Highway 2 consists of two Amtrak trains per day; two merchandise trains per day, six times per week (100 cars per train); and four grain trains per week (104 cars per train). The merchandise and grain trains make stops in Devils Lake to pick up/drop off cargo and then continue on in the same direction.

    b. The detour costs for Amtrak trains were based on a conversation with Gary Erford, Produce Line Director, Amtrak. If the rail line along US Highway 2 were closed, Amtrak trains would be rerouted from Fargo, northwest to Minot (along Highway 52... hereafter called the lower track). Consequently, there would be no Amtrak service for Grand Forks, Devils Lake and Rugby.

    c. The lost service to the three cities for Amtrak was estimated to result in approximately $100,000 per year revenue to Amtrak. Although bus service could be used to transport passengers from Grand Forks, Devils Lake, and Rugby to Minot or Fargo at a cost of $365,000 per year, it was assumed that service would be stopped to these three cities. The updated value for lost train service is $106,000.

    d. The other Amtrak damage involved in abandoning the track along US Highway 2 is the lost time due to congestion on the Fargo-Minot line (the lower track). When Amtrak first switched over to the lower track during the 1997 floods, their trains had delays of 1 to 2 hours per trip. However, after the fleeting was better organized, the delay was down to 30 minutes. This is considered a better estimate of a typical Amtrak delay along this line. This delay does not take into account

those times that bad weather or mechanical failure cause extreme hold-ups along the line. The cost associated with delay is $155 per minute, based on Amtrak computations. This 30-minute delay at $155 per minute was assumed for this study, and incorporates passenger time, crew over time and fuel. The updated cost associated with the delay is $164 per minute.

e. Data for the grain and merchandise train detour costs are based on conversation with Doug Chapel, Train Master of North Dakota in Fargo—in charge of the Burlington Northern line between Minot and Grand Forks and with Chuck Wendt, Superintendent of Operations in Fargo.

f. Doug Chapel stressed the issue of congestion on the would-be detour line from Fargo to Minot (the lower track). Amtrak trains are on the upper Devils Lake line because of the difficulties of congestion on the lower line, not because Amtrak business is booming in Devils Lake. Routing trains on the lower line would be more of a short-term fix rather than an easy solution to an abandoned track through Devils Lake.

g. John Quiltey, the BNR Head of the Locomotive Engineers in Forth Worth, TX and Skip Trader, also of the BNR Fort Worth Office, were contacted regarding detour costs.

h. The detour costs for merchandise and grain trains were based on fuel costs and crew overtime using Amtrak's 30-minute delay and assuming the detoured trains travel at 70 mph. An equivalent detour mileage for the time delay is then 35 miles.

i. Fuel costs for 1997 of $0.684/gal were assumed, based on conversations with Mr. Skip Trader (BNSF Fort Worth). Fuel efficiency is based on a Gross Ton Mile/Gal figure, at 711 ton mile/gal for 1997. In other words, 711 gross tons (material plus car weight) were transported 1 mile using 1 gallon of diesel fuel. The updated fuel cost is $0.725/gal.

j. The average capacity of grain and merchandise cars was obtained from the BNSF Railroad web site—an average agricultural car capacity of 134 gross tons and an average boxcar capacity of 120 gross tons.

k. The average crew required to operate a train was assumed to be three, plus one more person for switch operation. Dennis Mead (BNSF Payroll) stated that the crew members get paid on a mileage basis until a certain limit is reached. After that, a lot of other add-ons occur and that no general assumptions could be made for the 30 additional minutes of crew delay time. Therefore, the crew was assumed to be paid at an average hourly rate of $25/hr/person and that delays would be paid at 1.5 the normal rate. The updated average hourly rate is $26.50/hr/person.

l. The detour costs do not account for trucking of merchandise and grain to/from Devils Lake. However, if the track along US Highway 2 is under water, the viability of commerce in Devils

Lake is questionable and there may not be as great a need for merchandise and grain shipment to/from Devils Lake.

m. The detour costs also do not address the possibility of additional delays that other existing trains would experience due to the additional traffic from the upper track. However, five more trains per day on the lower track may not make much difference to the trains already there, especially if fleeting is well coordinated.

2. Recent surveys (2001) indicate that this segment of the BNSF has 3 signaling stations that would need to be replaced if the railroad is raised. The replacement cost for the signaling network (i.e. all 3 signaling stations) is estimated to be $850,000. The signaling network would need to be replaced for each incremental railroad raise.

3. Recent surveys (2001) indicate that railroad raises would affect 3 road crossings. The cost to rebuild each crossing is estimated to be $1,000 per track-foot and the typical track-foot length is 30 feet; therefore, the total estimated rebuild cost would be $30,000.

General Assumptions

1. Costs of railroad raises and restorations were obtained from *Devils Lake Flood Control: Economics Database Update: Transportation Report,* Barr Engineering Company, January 1998. These costs were updated for 2001 based on conversations with area railroad companies as follows:

   a. Filter fabric will no longer be placed under riprap for railroad raises; therefore, filter fabric costs were not included in the analysis.

   b. Riprap costs have increased from $20 per cubic yard to $30 per cubic yard due to inflation and scarcity of materials in the area.

   c. Fill costs have increased from $4.50 per cubic yard to $9 per cubic yard based on current costs in the area.

   d. Costs to install rails, ties and ballast were estimated at $135 per linear foot, which is representative of the cost of current installation methods in the area.

   e. Estimated railroad bridge raise costs were decreased from $500,000 per 100-foot bridge to $212,000 per 100-foot bridge based on new information on construction methods.

   f. Side slopes for raises and repair of rail beds were assumed to be 2:1 instead of 3:1,based on new information on construction methods. This revised assumption was also made for the side slopes of existing rail beds.

   g. Detour damages for rail abandonment were inflated to 2001 dollars.

2. It was assumed that decisions on protection would occur when the lake level is 1 foot below the top of the lowest rail bed.

3. If the railroad feature has a bridge with a low chord below the lowest rail bed, no decision will occur until the lake level is within 1 foot of the top of the lowest rail bed.

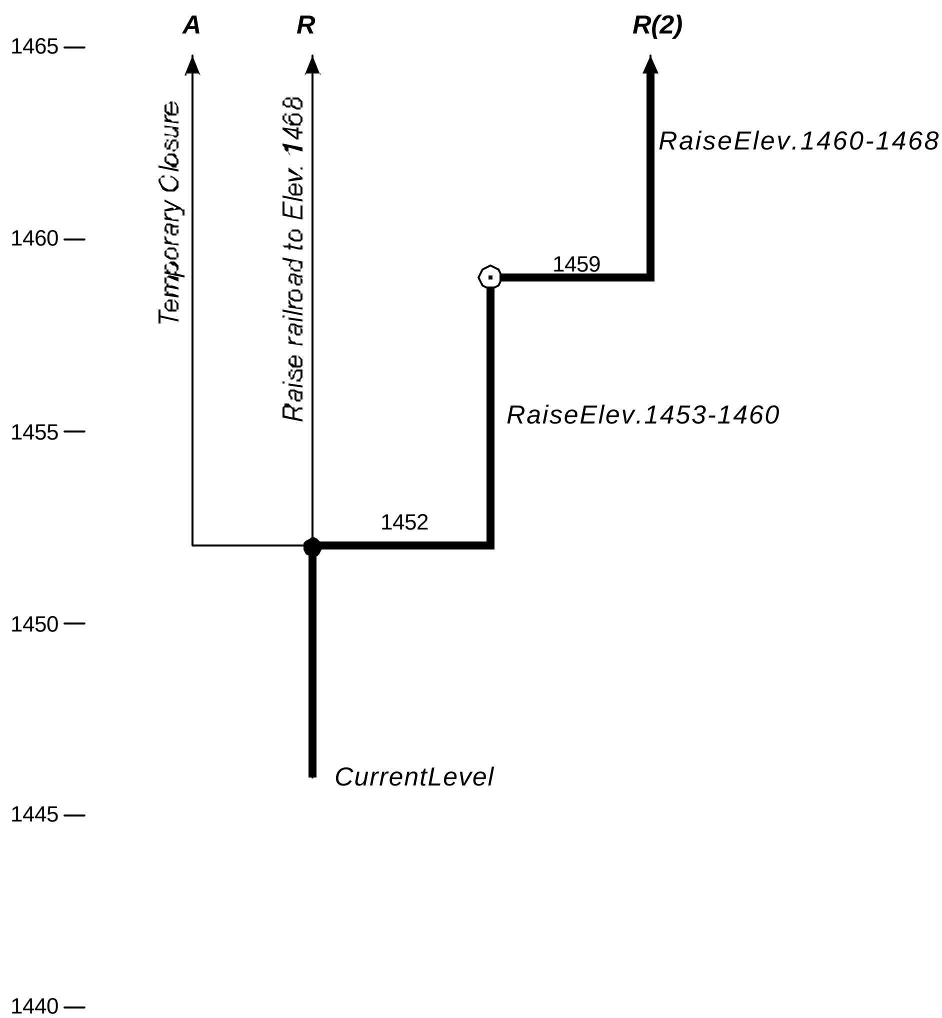
4. If railroads are temporarily closed during flooding, they were assumed to be restored when the lake recedes. Although some spur lines have been abandoned in recent years due to a loss of profitability of the lines, representatives of the respective railroads have indicated that they have no plans to abandon these specific spur lines and have indicated they would restore them if they were temporarily flooded. Burlington Northern Railroad does have a legal commitment to limit the total miles of tracks abandoned in the state, but can abandon a line if it is out of service for 2 years or more (based on a conversation with Don Laschkewitsch, Transportation Senior Manager, Railroads, NDDOT). For this study, it was assumed that the tracks would not be abandoned, but may be temporarily closed during flooding and restored when the lake recedes to 1 foot below the top of the lowest rail bed (again, with the exception of Feature 9).

Figure 2.11-1

LOCATION MAP
FEATURE 11: BURLINGTON NORTHERN RAILROAD
(ALONG US HIGHWAY 2)
Devils Lake Infrastructure Protection Study

DATA: 1997 USGS Digital Ortho Quad.

Barr: Arcview 3.1, PIIIAF, I:\Client\DevilsLake\Gis\DLIP\Features\RoadandRails\Rails\11_BN_Hwy2\Project\basemap_11.apr, Layout: Layout: Section 2 Figure BN RR along Hwy 2, lkp, Tue Nov 05 09:48:23 2002



Lowest RailElevation:1453

FloodProtectionStrategy

Decisionrequiredatthispoint

Triggerpointforaction,nodecisionneeded

R(1) Incrementalrailroadraise(numberoftimes)

R Railroadraiseto1468

A Temporary Closure

Figure 2.11-2

DECISION TREE
FEATURE 11:BURLINGTONNORTHERNRAILROAD
(AlongU.S.Highway2)
DevilsLakeInfrastructure ProtectionStudy

Table 2.11-1

Flood Damages
Feature 11: Burlington Northern Railroad (Along US Highway 2)
Devils Lake Infrastructure Protection Study

DAMAGES

Action Levels	Annual Detour Damages
	(THOUSANDS)
AL1 - AL2	$4,141

DAMAGE BREAKDOWN

Damage	AL1 - AL2				
	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Annual Detour Damages	Burlington Northern Railroad				
	BNSF - Grain Trains	1	LS	$113,201	$113
	BNSF - Merchandise Trains	1	LS	$298,928	$299
	AMTRACK	1	LS	$3,494,500	$3,495
	Subtotal				$3,907
	2001 Total (add inflation)				$4,141
	Total				**$4,141**

Restoration Damages																	
		Excavation				Fill				Rail Material				Bridge Repair			
Elevation	Total (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)
1452	$0																
1453	$2,897	21,083	CY	$2.65	$56	21,083	CY	$9.00	$190	16,500	LF	$135	$2,228	2	EA	$212,000	$424
1454	$2,897	21,083	CY	$2.65	$56	21,083	CY	$9.00	$190	16,500	LF	$135	$2,228	2	EA	$212,000	$424
1455	$2,897	21,083	CY	$2.65	$56	21,083	CY	$9.00	$190	16,500	LF	$135	$2,228	2	EA	$212,000	$424
1456	$2,912	21,211	CY	$2.65	$56	21,211	CY	$9.00	$191	16,600	LF	$135	$2,241	2	EA	$212,000	$424
1457	$2,912	21,211	CY	$2.65	$56	21,211	CY	$9.00	$191	16,600	LF	$135	$2,241	2	EA	$212,000	$424
1458	$4,201	32,200	CY	$2.65	$85	32,200	CY	$9.00	$290	25,200	LF	$135	$3,402	2	EA	$212,000	$424
1459	$5,093	39,803	CY	$2.65	$105	39,803	CY	$9.00	$358	31,150	LF	$135	$4,205	2	EA	$212,000	$424
1460	$5,093	39,803	CY	$2.65	$105	39,803	CY	$9.00	$358	31,150	LF	$135	$4,205	2	EA	$212,000	$424
1461	$9,230	75,069	CY	$2.65	$199	75,069	CY	$9.00	$676	58,750	LF	$135	$7,931	2	EA	$212,000	$424
1462	$10,032	81,906	CY	$2.65	$217	81,906	CY	$9.00	$737	64,100	LF	$135	$8,654	2	EA	$212,000	$424
1463	$12,205	100,433	CY	$2.65	$266	100,433	CY	$9.00	$904	78,600	LF	$135	$10,611	2	EA	$212,000	$424

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. 2001 Total for annual detour damages is equal to the 1998 Total cost multiplied by 6% to increase for inflation.

Table 2.11-2

Flood Protection Costs
Feature 11: Burlington Northern Railroad (Along US Highway 2
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Action Level	Lake Elevation	R Maximum Raise at AL1	A Temporary Closure at AL1	R(1)A Raise at AL1; Temporary Closure at AL2	R(2) Raise at AL1, AL2
	(MSL)	(THOUSANDS)			
AL1	1454	$63,879	$0	$16,452	$16,452
AL2	1459	$0	$0	$0	$47,427

COST BREAKDOWN

		R									
		R(1)A									
		R(2)					R(2)				
		Lake Elevation 1454					Lake Elevation 1459				
Strategy		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Incremental Raise											
	Rail Raise	Burlington Northern Railroad					Burlington Northern Railroad				
		Fill	197,909	CY	$9.00	$1,781	Fill	1,524,490	CY	$9.00	$13,720
		Riprap	283,672	CY	$30.00	$8,510	Riprap	882,469	CY	$30.00	$26,474
		Rail	42,050	LF	$135.00	$5,677	Rail	49,990	LF	$135.00	$6,749
		Bridge Raise	2	EA	$212,000	$424	Bridge Raise	2	EA	$212,000	$424
		Rail Crossing Raise	2	EA	$30,000	$60	Rail Crossing Raise	2	EA	$30,000	$60
		Total				**$16,452**	**Total**				**$47,427**

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. The costs for the Maximum Raise at AL1 strategy (R) is equal to the sum of the costs for all incremental raises.

Table 2.11 - 3

Economic Analysis of Strategies for Burlington Northern Railroad: Along US Highway 2 (Feature 11)

Strategy		Stochastic Analysis (ST) Mean Value over 10,000 Traces (Annual)							
		COSTS		DAMAGES			Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Total	Restoration	Detour	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D	E = C + D	F = E(A) - E(S) *	G = F - B	I = F / B
A	Temporary Closure During Floods at First Action Level	$0	$0	$25,800	$349,100	$375,000	$0	$0	--
R	Rail Raise to 1468	$717,200	$717,200	$0	$0	$0	$375,000	-$342,200	0.52
R(2)	2 Incr. Rail Raises	$294,100	$294,100	$0	$0	$0	$375,000	$80,800	1.28

Strategy		Wet Future Scenario (WF) (Annual)							
		COSTS		DAMAGES			Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Total	Restoration	Detour	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D	E = C + D	F = E(A) - E(S) *	G = F - B	I = F / B
A	Temporary Closure During Floods at First Action Level	$0	$0	$79,700	$2,918,300	$2,997,900	$0	$0	--
R	Rail Raise to 1468	$3,198,900	$3,198,900	$0	$0	$0	$2,997,900	-$200,900	0.94
R(2)	2 Incr. Rail Raises	$2,248,900	$2,248,900	$0	$0	$0	$2,997,900	$749,000	1.33

Strategy		Moderate Future 1 Scenario (M1) (Annual)							
		COSTS		DAMAGES			Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Total	Restoration	Detour	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D	E = C + D	F = E(A) - E(S) *	G = F - B	I = F / B
A	Temporary Closure During Floods at First Action Level	$0	$0	$0	$0	$0	$0	$0	--
R	Rail Raise to 1468	$0	$0	$0	$0	$0	$0	$0	--
R(2)	2 Incr. Rail Raises	$0	$0	$0	$0	$0	$0	$0	--

Strategy		Moderate Future 2 Scenario (M2) (Annual)							
		COSTS		DAMAGES			Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Total	Restoration	Detour	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D	E = C + D	F = E(A) - E(S) *	G = F - B	I = F / B
A	Temporary Closure During Floods at First Action Level	$0	$0	$63,600	$640,300	$704,000	$0	$0	--
R	Rail Raise to 1468	$2,075,500	$2,075,500	$0	$0	$0	$704,000	-$1,371,500	0.34
R(2)	2 Incr. Rail Raises	$495,300	$495,300	$0	$0	$0	$704,000	$208,600	1.42

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.375% and rounded to the nearest $100.

* Total benefits are calculated as the total damages incurred for "temporary closure strategy" minus the total damages for the strategy implemented (E(S)).

Attachment to 2.11:
Burlington Northern Railroad (along US Highway 2) Economic Analysis Assumptions

1. The track along US Highway 2 is a transcontinental freight route that extends from the State of New York to the State of Washington (through the City of Devils Lake). Amtrak passenger routes use the track and many other companies use the track for shipping a variety of products across the country. Burlington Northern and Sante Fe Railway Company (BNSF) has no plans to temporarily close this line because it would affect so many train routes (conversation with Cliff Inman, BNSF). During rapid rises in the lake level, this line might experience inadvertent closure(s) due to wave action damages or subbase failure from long-term submergence of the rail bed. As with CPR, rerouting the BNSF tracks is not considered a feasible option. Therefore, rerouting tracks was not considered as a strategy in this study. Consequently, the only protection strategy evaluated for this feature is rail raises. For the no protection strategy, detour damages were estimated based on assumptions described in the following paragraphs (a – m). **These detour damages were estimated in 1998, therefore they were updated for inflation by multiplying them by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001. The 1998 assumptions are as follows:**

    a. In general, the train traffic that runs through Devils Lake along US Highway 2 consists of two Amtrak trains per day; two merchandise trains per day, six times per week (100 cars per train); and four grain trains per week (104 cars per train). The merchandise and grain trains make stops in Devils Lake to pick up/drop off cargo and then continue on in the same direction.

    b. The detour costs for Amtrak trains were based on a conversation with Gary Erford, Produce Line Director, Amtrak. If the rail line along US Highway 2 were closed, Amtrak trains would be rerouted from Fargo, northwest to Minot (along Highway 52... hereafter called the lower track). Consequently, there would be no Amtrak service for Grand Forks, Devils Lake and Rugby.

    c. The lost service to the three cities for Amtrak was estimated to result in approximately $100,000 per year revenue to Amtrak. Although bus service could be used to transport passengers from Grand Forks, Devils Lake, and Rugby to Minot or Fargo at a cost of $365,000 per year, it was assumed that service would be stopped to these three cities. The updated value for lost train service is $106,000.

    d. The other Amtrak damage involved in abandoning the track along US Highway 2 is the lost time due to congestion on the Fargo-Minot line (the lower track). When Amtrak first switched over to the lower track during the 1997 floods, their trains had delays of 1 to 2 hours per trip. However, after the fleeting was better organized, the delay was down to 30 minutes. This is considered a better estimate of a typical Amtrak delay along this line. This delay does not take into account

those times that bad weather or mechanical failure cause extreme hold-ups along the line. The cost associated with delay is $155 per minute, based on Amtrak computations. This 30-minute delay at $155 per minute was assumed for this study, and incorporates passenger time, crew over time and fuel. The updated cost associated with the delay is $164 per minute.

e. Data for the grain and merchandise train detour costs are based on conversation with Doug Chapel, Train Master of North Dakota in Fargo—in charge of the Burlington Northern line between Minot and Grand Forks and with Chuck Wendt, Superintendent of Operations in Fargo.

f. Doug Chapel stressed the issue of congestion on the would-be detour line from Fargo to Minot (the lower track). Amtrak trains are on the upper Devils Lake line because of the difficulties of congestion on the lower line, not because Amtrak business is booming in Devils Lake. Routing trains on the lower line would be more of a short-term fix rather than an easy solution to an abandoned track through Devils Lake.

g. John Quiltey, the BNR Head of the Locomotive Engineers in Forth Worth, TX and Skip Trader, also of the BNR Fort Worth Office, were contacted regarding detour costs.

h. The detour costs for merchandise and grain trains were based on fuel costs and crew overtime using Amtrak's 30-minute delay and assuming the detoured trains travel at 70 mph. An equivalent detour mileage for the time delay is then 35 miles.

i. Fuel costs for 1997 of $0.684/gal were assumed, based on conversations with Mr. Skip Trader (BNSF Fort Worth). Fuel efficiency is based on a Gross Ton Mile/Gal figure, at 711 ton mile/gal for 1997. In other words, 711 gross tons (material plus car weight) were transported 1 mile using 1 gallon of diesel fuel. The updated fuel cost is $0.725/gal.

j. The average capacity of grain and merchandise cars was obtained from the BNSF Railroad web site—an average agricultural car capacity of 134 gross tons and an average boxcar capacity of 120 gross tons.

k. The average crew required to operate a train was assumed to be three, plus one more person for switch operation. Dennis Mead (BNSF Payroll) stated that the crew members get paid on a mileage basis until a certain limit is reached. After that, a lot of other add-ons occur and that no general assumptions could be made for the 30 additional minutes of crew delay time. Therefore, the crew was assumed to be paid at an average hourly rate of $25/hr/person and that delays would be paid at 1.5 the normal rate. The updated average hourly rate is $26.50/hr/person.

l. The detour costs do not account for trucking of merchandise and grain to/from Devils Lake. However, if the track along US Highway 2 is under water, the viability of commerce in Devils

Lake is questionable and there may not be as great a need for merchandise and grain shipment to/from Devils Lake.

m. The detour costs also do not address the possibility of additional delays that other existing trains would experience due to the additional traffic from the upper track. However, five more trains per day on the lower track may not make much difference to the trains already there, especially if fleeting is well coordinated.

2. Recent surveys (2001) indicate that this segment of the BNSF has 3 signaling stations that would need to be replaced if the railroad is raised. The replacement cost for the signaling network (i.e. all 3 signaling stations) is estimated to be $850,000. The signaling network would need to be replaced for each incremental railroad raise.

3. Recent surveys (2001) indicate that railroad raises would affect 3 road crossings. The cost to rebuild each crossing is estimated to be $1,000 per track-foot and the typical track-foot length is 30 feet; therefore, the total estimated rebuild cost would be $30,000.

General Assumptions

1. Costs of railroad raises and restorations were obtained from *Devils Lake Flood Control: Economics Database Update: Transportation Report,* Barr Engineering Company, January 1998. These costs were updated for 2001 based on conversations with area railroad companies as follows:

   a. Filter fabric will no longer be placed under riprap for railroad raises; therefore, filter fabric costs were not included in the analysis.

   b. Riprap costs have increased from $20 per cubic yard to $30 per cubic yard due to inflation and scarcity of materials in the area.

   c. Fill costs have increased from $4.50 per cubic yard to $9 per cubic yard based on current costs in the area.

   d. Costs to install rails, ties and ballast were estimated at $135 per linear foot, which is representative of the cost of current installation methods in the area.

   e. Estimated railroad bridge raise costs were decreased from $500,000 per 100-foot bridge to $212,000 per 100-foot bridge based on new information on construction methods.

   f. Side slopes for raises and repair of rail beds were assumed to be 2:1 instead of 3:1, based on new information on construction methods. This revised assumption was also made for the side slopes of existing rail beds.

   g. Detour damages for rail abandonment were inflated to 2001 dollars.

2. It was assumed that decisions on protection would occur when the lake level is 1 foot below the top of the lowest rail bed.

3. If the railroad feature has a bridge with a low chord below the lowest rail bed, no decision will occur until the lake level is within 1 foot of the top of the lowest rail bed.

4. If railroads are temporarily closed during flooding, they were assumed to be restored when the lake recedes. Although some spur lines have been abandoned in recent years due to a loss of profitability of the lines, representatives of the respective railroads have indicated that they have no plans to abandon these specific spur lines and have indicated they would restore them if they were temporarily flooded. Burlington Northern Railroad does have a legal commitment to limit the total miles of tracks abandoned in the state, but can abandon a line if it is out of service for 2 years or more (based on a conversation with Don Laschkewitsch, Transportation Senior Manager, Railroads, NDDOT). For this study, it was assumed that the tracks would not be abandoned, but may be temporarily closed during flooding and restored when the lake recedes to 1 foot below the top of the lowest rail bed (again, with the exception of Feature 9).

Attachment to 2.11:
Burlington Northern Railroad (along US Highway 2) Economic Analysis Assumptions

1. The track along US Highway 2 is a transcontinental freight route that extends from the State of New York to the State of Washington (through the City of Devils Lake). Amtrak passenger routes use the track and many other companies use the track for shipping a variety of products across the country. Burlington Northern and Sante Fe Railway Company (BNSF) has no plans to temporarily close this line because it would affect so many train routes (conversation with Cliff Inman, BNSF). During rapid rises in the lake level, this line might experience inadvertent closure(s) due to wave action damages or subbase failure from long-term submergence of the rail bed. As with CPR, rerouting the BNSF tracks is not considered a feasible option. Therefore, rerouting tracks was not considered as a strategy in this study. Consequently, the only protection strategy evaluated for this feature is rail raises. For the no protection strategy, detour damages were estimated based on assumptions described in the following paragraphs (a – m). **These detour damages were estimated in 1998, therefore they were updated for inflation by multiplying them by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001. The 1998 assumptions are as follows:**

    a. In general, the train traffic that runs through Devils Lake along US Highway 2 consists of two Amtrak trains per day; two merchandise trains per day, six times per week (100 cars per train); and four grain trains per week (104 cars per train). The merchandise and grain trains make stops in Devils Lake to pick up/drop off cargo and then continue on in the same direction.

    b. The detour costs for Amtrak trains were based on a conversation with Gary Erford, Produce Line Director, Amtrak. If the rail line along US Highway 2 were closed, Amtrak trains would be rerouted from Fargo, northwest to Minot (along Highway 52... hereafter called the lower track). Consequently, there would be no Amtrak service for Grand Forks, Devils Lake and Rugby.

    c. The lost service to the three cities for Amtrak was estimated to result in approximately $100,000 per year revenue to Amtrak. Although bus service could be used to transport passengers from Grand Forks, Devils Lake, and Rugby to Minot or Fargo at a cost of $365,000 per year, it was assumed that service would be stopped to these three cities. The updated value for lost train service is $106,000.

    d. The other Amtrak damage involved in abandoning the track along US Highway 2 is the lost time due to congestion on the Fargo-Minot line (the lower track). When Amtrak first switched over to the lower track during the 1997 floods, their trains had delays of 1 to 2 hours per trip. However, after the fleeting was better organized, the delay was down to 30 minutes. This is considered a better estimate of a typical Amtrak delay along this line. This delay does not take into account

those times that bad weather or mechanical failure cause extreme hold-ups along the line. The cost associated with delay is $155 per minute, based on Amtrak computations. This 30-minute delay at $155 per minute was assumed for this study, and incorporates passenger time, crew over time and fuel. The updated cost associated with the delay is $164 per minute.

e. Data for the grain and merchandise train detour costs are based on conversation with Doug Chapel, Train Master of North Dakota in Fargo—in charge of the Burlington Northern line between Minot and Grand Forks and with Chuck Wendt, Superintendent of Operations in Fargo.

f. Doug Chapel stressed the issue of congestion on the would-be detour line from Fargo to Minot (the lower track). Amtrak trains are on the upper Devils Lake line because of the difficulties of congestion on the lower line, not because Amtrak business is booming in Devils Lake. Routing trains on the lower line would be more of a short-term fix rather than an easy solution to an abandoned track through Devils Lake.

g. John Quiltey, the BNR Head of the Locomotive Engineers in Forth Worth, TX and Skip Trader, also of the BNR Fort Worth Office, were contacted regarding detour costs.

h. The detour costs for merchandise and grain trains were based on fuel costs and crew overtime using Amtrak's 30-minute delay and assuming the detoured trains travel at 70 mph. An equivalent detour mileage for the time delay is then 35 miles.

i. Fuel costs for 1997 of $0.684/gal were assumed, based on conversations with Mr. Skip Trader (BNSF Fort Worth). Fuel efficiency is based on a Gross Ton Mile/Gal figure, at 711 ton mile/gal for 1997. In other words, 711 gross tons (material plus car weight) were transported 1 mile using 1 gallon of diesel fuel. The updated fuel cost is $0.725/gal.

j. The average capacity of grain and merchandise cars was obtained from the BNSF Railroad web site—an average agricultural car capacity of 134 gross tons and an average boxcar capacity of 120 gross tons.

k. The average crew required to operate a train was assumed to be three, plus one more person for switch operation. Dennis Mead (BNSF Payroll) stated that the crew members get paid on a mileage basis until a certain limit is reached. After that, a lot of other add-ons occur and that no general assumptions could be made for the 30 additional minutes of crew delay time. Therefore, the crew was assumed to be paid at an average hourly rate of $25/hr/person and that delays would be paid at 1.5 the normal rate. The updated average hourly rate is $26.50/hr/person.

l. The detour costs do not account for trucking of merchandise and grain to/from Devils Lake. However, if the track along US Highway 2 is under water, the viability of commerce in Devils

Lake is questionable and there may not be as great a need for merchandise and grain shipment to/from Devils Lake.

m. The detour costs also do not address the possibility of additional delays that other existing trains would experience due to the additional traffic from the upper track. However, five more trains per day on the lower track may not make much difference to the trains already there, especially if fleeting is well coordinated.

2. Recent surveys (2001) indicate that this segment of the BNSF has 3 signaling stations that would need to be replaced if the railroad is raised. The replacement cost for the signaling network (i.e. all 3 signaling stations) is estimated to be $850,000. The signaling network would need to be replaced for each incremental railroad raise.

3. Recent surveys (2001) indicate that railroad raises would affect 3 road crossings. The cost to rebuild each crossing is estimated to be $1,000 per track-foot and the typical track-foot length is 30 feet; therefore, the total estimated rebuild cost would be $30,000.

General Assumptions

1. Costs of railroad raises and restorations were obtained from *Devils Lake Flood Control: Economics Database Update: Transportation Report,* Barr Engineering Company, January 1998. These costs were updated for 2001 based on conversations with area railroad companies as follows:

   a. Filter fabric will no longer be placed under riprap for railroad raises; therefore, filter fabric costs were not included in the analysis.

   b. Riprap costs have increased from $20 per cubic yard to $30 per cubic yard due to inflation and scarcity of materials in the area.

   c. Fill costs have increased from $4.50 per cubic yard to $9 per cubic yard based on current costs in the area.

   d. Costs to install rails, ties and ballast were estimated at $135 per linear foot, which is representative of the cost of current installation methods in the area.

   e. Estimated railroad bridge raise costs were decreased from $500,000 per 100-foot bridge to $212,000 per 100-foot bridge based on new information on construction methods.

   f. Side slopes for raises and repair of rail beds were assumed to be 2:1 instead of 3:1,based on new information on construction methods. This revised assumption was also made for the side slopes of existing rail beds.

   g. Detour damages for rail abandonment were inflated to 2001 dollars.

2. It was assumed that decisions on protection would occur when the lake level is 1 foot below the top of the lowest rail bed.

3. If the railroad feature has a bridge with a low chord below the lowest rail bed, no decision will occur until the lake level is within 1 foot of the top of the lowest rail bed.

4. If railroads are temporarily closed during flooding, they were assumed to be restored when the lake recedes. Although some spur lines have been abandoned in recent years due to a loss of profitability of the lines, representatives of the respective railroads have indicated that they have no plans to abandon these specific spur lines and have indicated they would restore them if they were temporarily flooded. Burlington Northern Railroad does have a legal commitment to limit the total miles of tracks abandoned in the state, but can abandon a line if it is out of service for 2 years or more (based on a conversation with Don Laschkewitsch, Transportation Senior Manager, Railroads, NDDOT). For this study, it was assumed that the tracks would not be abandoned, but may be temporarily closed during flooding and restored when the lake recedes to 1 foot below the top of the lowest rail bed (again, with the exception of Feature 9).

2.12 Summary of Economic Analysis Investigation for Feature 12: Burlington Northern Railroad (Churchs Ferry to Cando)

2.12.0 Flood Protection Strategy

The flood protection strategy that was analyzed in the Economic Analysis of Devils Lake Alternatives for Burlington Northern Railroad (Churchs Ferry to Cando) was incremental rail raises.

2.12.1 General Information

Feature Type: Railroad

Location: Feature 12 is the section of the Burlington Northern Railroad from Churchs Ferry to Cando. The accompanying Figure 2.12-1 shows the feature's location and approximate extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: Feature 12 is a railroad. The rail line is constructed on raised embankments traversing overland. There are two bridges and two road crossings in this stretch of track.

Significance: The Burlington Northern Railroad (Churchs Ferry to Cando) is important because the track carries an average of approximately 100 cars per month. The cars transport primarily grain and fertilizer. If the track were closed, the freight would require another means of shipping such as trucking, which is more expensive.

Damages: The flooding of the Burlington Northern Railroad (Churchs Ferry to Cando) would result in the following damages:

- restoration cost
- alternate shipping/detour costs

Owner/Sponsor: The Burlington Northern and Sante Fe Railway Company (BNSF) is responsible for managing and maintaining Feature 12.

Lead Federal Agency: The Corps of Engineers would take the lead for the Burlington Northern Railroad (Churchs Ferry to Cando) for any flood protection work that may take place. The Federal Railway Administration may provide funding.

2.12.2 Feature Protection

History of Flood Protection: In the past, flood protection for the Burlington Northern Railroad (Churchs Ferry to Cando) has not been an issue. Previous or current lake levels have not affected the track.

General Protection Strategy: The Economic Analysis of Devils Lake Alternatives analysis identified and evaluated several different approaches for protecting the Burlington Northern Railroad (Churchs Ferry to Cando). These included:

- rerouting railroad to higher ground (this strategy was dropped based on discussions with Burlington Northern Railroad staff)
- raising the tracks

Protection Strategy by Lake Level: The Economic Analysis of Devils Lake Alternatives analyzed the flood protection strategy of raising the rail line, with flood protection decisions being made at various lake levels as Devils Lake continued to rise. Figure 2.12-2 shows the decision tree for Burlington Northern Railroad (Churchs Ferry to Cando). As shown on Figure 2.12-2, the stepwise approach to flood protection for Burlington Northern Railroad (Churchs Ferry to Cando) that was analyzed consisted of the following:

1. At lake elevation 1454, a decision would be made as to whether the rail line would be raised to 1460, or temporarily closed.
2. If the rail line were raised at the first action level, at lake elevation 1459, a decision would be made as to whether the rail line would be raised to 1468, or temporarily closed.

The maximum protection strategy that was analyzed at the first action level was raising the rail line to 1468. (Note that for the analysis, the decision regarding whether or not to raise the rail line is made at a time when the lake is one foot below the minimum rail elevation that resulted from the most recent raise.)

Interdependencies: The protection of Feature 12, Burlington Northern Railroad (Churchs Ferry to Cando), is related to the protection of Feature 1, Churchs Ferry. Temporary closure of Feature 12 would affect the transport of materials in and out of Churchs Ferry.

Table 2.0-1, mentioned earlier in this report, provides a summary of the interdependencies among the features.

2.12.3 Feature Economics

Damages: For the Burlington Northern Railroad (Churchs Ferry to Cando), the damages resulting from flooding were estimated up to the maximum lake level (1463). The damage computations for Feature 12 are summarized in the accompanying Table 2.12–1.

The first portion of the table summarizes the detour and restoration damages. The second portion of the table is a breakdown of the annual detour damages and the restoration damages associated with each action level. Annual detour damage represents the cost for alternate shipping methods and/or routes when the rail line is temporarily closed. Restoration damages include rebuilding the rail with excavation, fill, rail material, and bridge repairs. Restoration damages are a per-event damage. They are only incurred when and if the lake recedes below the rail bed after a period of flooding. Restoration damages depend on the lake level during the period of flooding because the extent of the rail line that needs restoration depends on the extent of flooding.

Unit costs for all the damage computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for Feature 12 are listed in the Burlington Northern Railroad (Churchs Ferry to Cando) Assumptions listing, appended to this Section 2.12.

Costs: The costs of providing flood protection for the Burlington Northern Railroad (Churchs Ferry to Cando) are detailed in the accompanying Table 2.12-2. Unit costs, data sources, and relevant assumptions are listed.

The first portion of the table shows the costs associated with each strategy for each action level (1454 and 1459). The second portion of the table is a breakdown of costs for raising tracks and railroad bridges. Itemized costs are broken down into six categories: fill, riprap, rail, bridge raise, rail crossing raise, and signaling station raise.

Unit costs for all the cost computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for Feature 12 are listed in the Burlington Northern Railroad (Churchs Ferry to Cando) Assumptions listing, appended to this Section 2.12.

2.12.4 Results of Economic Analysis

The results of the Economic Analysis for the Burlington Northern Railroad (Churchs Ferry to Cando) are listed in Table 2.12-3.

Stochastic Analysis Results: The stochastic analysis indicated that the net benefits for the incremental rail raises were less than one (-$180,400) and the BCR was 0.19. Therefore this strategy was not economically justified. This strategy is highlighted on the decision tree (Figure

2.12-2). The present worth annualized detour damages that would be prevented by this strategy were computed to be $27,000. The stochastic results are averages over 10,000 traces.

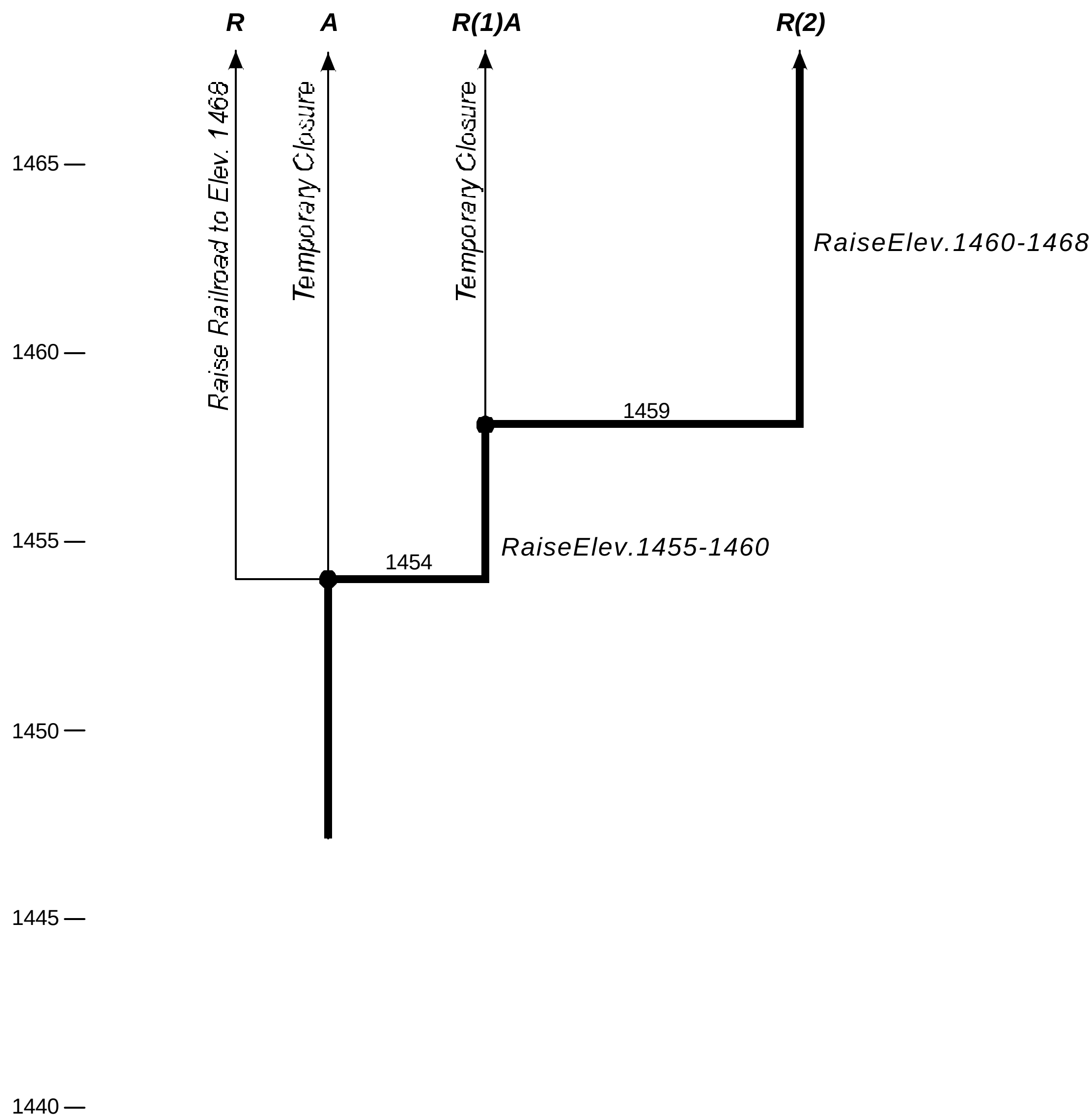
Results for Specific Scenarios: In the economic analysis, flood protection strategies were also analyzed for three specific climate futures. For Burlington Northern Railroad (Churchs Ferry to Cando), the identified strategy and the economic indices for each of the three climate futures are as follows:

- Wet Future – For the wet future, the protection strategy had negative net benefits (-$1,614,700) and a BCR of 0.19. Therefore, the protection strategy for Burlington Northern Railroad (Churchs Ferry to Cando) was not economically justified. For this future, the present worth annualized detour damages that would be prevented were computed at $295,700.
- First Moderate Future – For the first moderate future, lake levels do not reach first damage levels.
- Second Moderate Future – For the second moderate future, the strategy had net benefits that were -$396,100, and the BCR was 0.20, indicating that this strategy was not economically justified. For this future, the present worth annualized detour damages that would be prevented were computed at $67,500.

Figure 2.12-1
LOCATION MAP
FEATURE 12: BURLINGTON NORTHERN RAILROAD (CHURCHS FERRY TO CANDO)
Devils Lake Infrastructure Protection Study

Barr: Arcview 3.1, P:\V02, i:\client\devilslake\gis\dip\features\roadandrails\rails\t12_bn_cf_c\project\basemap_12.apr, Layout: Section 2 Base Map, lkp, Wed Oct 30 15:49:04 2002

DATA: 1997 USGS Digital Ortho Quad.



Lowest RailElevation:1455

FloodProtectionStrategy

Decisionrequiredatthispoint

Triggerpointforaction,nodecisionneeded

R(1) Incrementalrailroadraise(numberoftimes)

R Railroadraiseto1468

A Temporary closureofrailroad

Figure2.12-2

DECISION TREE
FEATURE 12:BURLINGTONNORTHERNRAILROAD
(ChurchsFerry toCando)
DevilsLakeInfrastructure ProtectionStudy

Table 2.12-1

Flood Damages
Feature 12: Burlington Northern Railroad (Churchs Ferry to Cando)
Devils Lake Infrastructure Protection Study

DAMAGES

Action Levels	Annual Detour Damages
	(THOUSANDS)
AL1 - AL2	$509

DAMAGE BREAKDOWN

Damage	AL1 - AL2				
	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Annual Detour Damages	Burlington Northern Railroad				
	BNSF - Grain Trains	1	LS	$480,000	$480
	Subtotal				$480
	2001 Total (add inflation)				$509
	Total				**$509**

Restoration Damages																	
		Excavation				Fill				Rail Material				Bridge Repair			
Elevation	Total (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)
1454	$0																
1455	$1,218	6,772	CY	$2.65	$18	6,772	CY	$9.00	$61	5,300	LF	$135	$716	2	EA	$212,000	$424
1456	$1,218	6,772	CY	$2.65	$18	6,772	CY	$9.00	$61	5,300	LF	$135	$716	2	EA	$212,000	$424
1457	$3,564	26,769	CY	$2.65	$71	26,769	CY	$9.00	$241	20,950	LF	$135	$2,828	2	EA	$212,000	$424
1458	$3,564	26,769	CY	$2.65	$71	26,769	CY	$9.00	$241	20,950	LF	$135	$2,828	2	EA	$212,000	$424
1459	$4,351	33,478	CY	$2.65	$89	33,478	CY	$9.00	$301	26,200	LF	$135	$3,537	2	EA	$212,000	$424
1460	$6,727	53,731	CY	$2.65	$142	53,731	CY	$9.00	$484	42,050	LF	$135	$5,677	2	EA	$212,000	$424
1461	$9,365	76,220	CY	$2.65	$202	76,219	CY	$9.00	$686	59,650	LF	$135	$8,053	2	EA	$212,000	$424
1462	$11,836	97,290	CY	$2.65	$258	97,290	CY	$9.00	$876	76,140	LF	$135	$10,279	2	EA	$212,000	$424
1463	$14,220	117,607	CY	$2.65	$312	117,607	CY	$9.00	$1,058	92,040	LF	$135	$12,425	2	EA	$212,000	$424

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. 2001 Total for annual detour damages is equal to the 1998 Total cost multiplied by 6% to increase for inflation.

Table 2.12-2

Flood Protection Costs
Feature 12: Burlington Northern Railroad (Churchs Ferry to Cando)
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Action Level	Lake Elevation	R Maximum Raise at AL1	A Temporary Closure at AL1	R(1)A Raise at AL1; Temporary Closure at AL2	R(2) Raise at AL1, AL2
	(MSL)	(THOUSANDS)			
AL1	1454	$69,394	$69,394	$16,561	$16,561
AL2	1459	$0	$0	$52,833	$52,833

COST BREAKDOWN

		R									
		R(1)A									
		R(2)					R(2)				
		Lake Elevation 1454					Lake Elevation 1459				
Strategy		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Incremental Raise											
	Rail Raise	Burlington Northern Railroad					Burlington Northern Railroad				
		Fill	292,819	CY	$9.00	$2,635	Fill	1,499,715	CY	$9.00	$13,497
		Riprap	278,553	CY	$30.00	$8,357	Riprap	942,850	CY	$30.00	$28,286
		Rail	31,150	LF	$135.00	$4,205	Rail	71,750	LF	$135.00	$9,686
		Bridge Raise	2	EA	$212,000	$424	Bridge Raise	2	EA	$212,000	$424
		Rail Crossing Raise	3	EA	$30,000	$90	Rail Crossing Raise	3	EA	$30,000	$90
		Signaling Station Rais	1	EA	$850,000	$850	Signaling Station Rais	1	EA	$850,000	$850
		Total				**$16,561**	**Total**				**$52,833**

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. The costs for the Maximum Raise at AL1 strategy (R) is equal to the sum of the costs for all incremental raises.

Table 2.12 - 3

Economic Analysis of Strategies for
Burlington Northern Railroad: US Highway 2 to Churchs Ferry
(Feature 12)

Strategy		Stochastic Analysis (ST) Mean Value over 10,000 Traces (Annual)							
		COSTS		DAMAGES			Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Total	Restoration	Detour	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D	E = C + D	F = E(A) - E(S) *	G = F - B	I = F / B
A	Temporary Closure During Floods at First Action Le	$0	$0	$15,900	$27,000	$42,900	$0	$0	--
R	Rail Raise to 1468	$438,100	$438,100	$0	$0	$0	$42,900	-$395,300	0.10
R(1)A	1 Rail Raise: Then Temporary Closure During Floo	$112,900	$112,900	$15,800	$6,300	$22,100	$20,800	-$92,000	0.18
R(2)	2 Incr. Rail Raises	$223,300	$223,300	$0	$0	$0	$42,900	-$180,400	0.19

Strategy		Wet Future Scenario (WF) (Annual)							
		COSTS		DAMAGES			Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Total	Restoration	Detour	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D	E = C + D	F = E(A) - E(S) *	G = F - B	I = F / B
A	Temporary Closure During Floods at First Action Le	$0	$0	$93,200	######	$389,000	$0	$0	--
R	Rail Raise to 1468	########	########	$0	$0	$0	$389,000	-$2,213,300	0.15
R(1)A	1 Rail Raise: Then Temporary Closure During Floo	$670,200	$670,200	$118,400	######	$243,400	$145,600	-$524,600	0.22
R(2)	2 Incr. Rail Raises	########	########	$0	$0	$0	$389,000	-$1,614,700	0.19

Strategy		Moderate Future 1 Scenario (M1) (Annual)							
		COSTS		DAMAGES			Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Total	Restoration	Detour	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D	E = C + D	F = E(A) - E(S) *	G = F - B	I = F / B
A	Temporary Closure During Floods at First Action Le	$0	$0	$0	$0	$0	$0	$0	--
R	Rail Raise to 1468	$0	$0	$0	$0	$0	$0	$0	--
R(1)A	1 Rail Raise: Then Temporary Closure During Floo	$0	$0	$0	$0	$0	$0	$0	--
R(2)	2 Incr. Rail Raises	$0	$0	$0	$0	$0	$0	$0	--

Strategy		Moderate Future 2 Scenario (M2) (Annual)							
		COSTS		DAMAGES			Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Total	Restoration	Detour	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D	E = C + D	F = E(A) - E(S) *	G = F - B	I = F / B
A	Temporary Closure During Floods at First Action Le	$0	$0	$28,500	$67,500	$96,000	$0	$0	--
R	Rail Raise to 1468	########	########	$0	$0	$0	$96,000	-$1,814,600	0.05
R(1)A	1 Rail Raise: Then Temporary Closure During Floo	$492,000	$492,000	$0	$0	$0	$96,000	-$396,100	0.20
R(2)	2 Incr. Rail Raises	$492,000	$492,000	$0	$0	$0	$96,000	-$396,100	0.20

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.375% and rounded to the nearest $100.

* Total benefits are calculated as the total damages incurred for "temporary closure strategy" minus the total damages for the strategy implemented (E(S)).

Attachment to 2.12:
Burlington Northern Railroad (Churchs Ferry to Cando) Economic Analysis Assumptions

1. According to John Heizman, Burlington Northern Railroad, this track carries an average of approximately 100 cars per month. It is difficult to estimate how much trucking would cost because the material shipped changes significantly throughout the year and involves both fertilizer and grain. It was assumed that the cost for trucking fertilizer and other commodities would be comparable to the trucking cost for grain at $400 per carload. Therefore, if the tracks were temporarily closed, annual damages would be $480,000. These annual damages were determined in 1998, therefore they were updated for inflation by multiplying them by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001. The inflated damages are $509,000.

2. Rerouting of the rail is not logical for this rail feature, as discussed in Features 10 and 11. Therefore, only temporary closure during flooding and rail raise scenarios is evaluated for this track.

3. Recent surveys indicate that railroad raises would affect 2 road crossings. The cost to rebuild each crossing is estimated to be $1,000 per track-foot and the typical track-foot length is 30 feet; therefore, the total estimated rebuild cost would be $30,000.

General Assumptions

1. Costs of railroad raises and restorations were obtained from *Devils Lake Flood Control: Economics Database Update: Transportation Report*, Barr Engineering Company, January 1998. These costs were updated for 2001 based on conversations with area railroad companies as follows:

   a. Filter fabric will no longer be placed under riprap for railroad raises; therefore, filter fabric costs were not included in the analysis.

   b. Riprap costs have increased from $20 per cubic yard to $30 per cubic yard due to inflation and scarcity of materials in the area.

   c. Fill costs have increased from $4.50 per cubic yard to $9 per cubic yard based on current costs in the area.

   d. Costs to install rails, ties and ballast were estimated at $135 per linear foot, which is representative of the cost of current installation methods in the area.

   e. Estimated railroad bridge raise costs were decreased from $500,000 per 100-foot bridge to $212,000 per 100-foot bridge based on new information on construction methods.

f. Side slopes for raises and repair of rail beds were assumed to be 2:1 instead of 3:1, based on new information on construction methods. This revised assumption was also made for the side slopes of existing rail beds.

g. Detour damages for rail abandonment were inflated to 2001 dollars.

2. It was assumed that decisions on protection would occur when the lake level is 1 foot below the top of the lowest rail bed.

3. If the railroad feature has a bridge with a low chord below the lowest rail bed, no decision will occur until the lake level is within 1 foot of the top of the lowest rail bed.

4. If railroads are temporarily closed during flooding, they were assumed to be restored when the lake recedes. Although some spur lines have been abandoned in recent years due to a loss of profitability of the lines, representatives of the respective railroads have indicated that they have no plans to abandon these specific spur lines and have indicated they would restore them if they were temporarily flooded. Burlington Northern Railroad does have a legal commitment to limit the total miles of tracks abandoned in the state, but can abandon a line if it is out of service for 2 years or more (based on a conversation with Don Laschkewitsch, Transportation Senior Manager, Railroads, NDDOT). For this study, it was assumed that the tracks would not be abandoned, but may be temporarily closed during flooding and restored when the lake recedes to 1 foot below the top of the lowest rail bed (again, with the exception of Feature 9).

2.13 Summary of Economic Analysis Investigation for Feature 13: US Highway 2

2.13.0 Flood Protection Strategy

The flood protection strategy that was analyzed in the Economic Analysis of Devils Lake Alternatives for US Highway 2 was incremental road raises.

2.13.1 General Information

Feature Type: Road

Location: Feature 13 is the portion of US Highway 2 that extends from 4 miles west of Churchs Ferry through the City of Devils Lake, east to a location south of Crary. This stretch is approximately 35 miles long and passes through the townships of Coulee, Dry Lake, Grand Harbor, Creel North, South Minnewaukan, and Stevens in Ramsey County. The accompanying Figure 2.13-1 shows the feature's location and approximate extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: US Highway 2 is a four-lane bituminous National Highway. The highway route spans nearly every state across the northern portion of the United States from Washington to Michigan and on to Maine.

Significance: This portion of US Highway 2 is important because it is a major traffic route in the area, including the main route between Churchs Ferry and Devils Lake. It is vital to serving local transportation, agricultural needs, and moving products through the area.

Damages: The flooding of Feature 13 would result in the following damages:

- Detour damages resulting from the added travel time and miles traveled when US Highway 2 is closed and traffic is detoured
- Restoration damages resulting from repairs that would be necessary to bring the highway back to a useable condition after a period of inundation

Owner/Sponsor: North Dakota Department of Transportation

Lead Federal Agency: The Federal Highway Administration would take the lead for US Highway 2 for any flood protection work that may take place.

2.13.2 Feature Protection

History of Flood Protection: Flood protection for US Highway 2 has not been an issue yet. Currently all of this section of road has been above of the level of the rising water.

General Protection Strategy: The Economic Analysis of Devils Lake Alternatives analysis identified and evaluated several different approaches for protecting US Highway 2. These included:

- rerouting the road to higher ground (this strategy was later dropped from consideration)
- raising the road

Protection Strategy by Lake Level: The Economic Analysis of Devils Lake Alternatives analyzed the flood protection strategy of raising the road, with flood protection decisions being made at various lake levels as Devils Lake continued to rise. Figure 2.13-2 shows the decision tree for US Highway 2. As shown on Figure 2.13-2, the stepwise approach to flood protection for US Highway 2 that was analyzed consisted of the following:

1. At lake elevation 1454, a decision would be made as to whether the road would be raised to 1460, or temporarily closed.
2. If the road were raised at the first action level, at lake elevation 1459 another decision would be made as to whether the road would be raised to 1468, or temporarily closed.

The maximum protection strategy that was analyzed at the first action level was raising the road to 1468. (Note that for the analysis, the decision regarding whether or not to raise the road is made at a time when the lake is one foot below the minimum highway elevation that resulted from the most recent raise.)

Interdependencies: The protection of US Highway 2 is related to the protection of the following features:

- Feature 1: Churchs Ferry – Feature 1 is located near the west end of Feature 13. The protection strategy chosen for US Highway 2 will have an impact on the traffic through Churchs Ferry.
- Feature 2: City of Devils Lake – Feature 2 is located in the middle of Feature 13. The protection strategy chosen for US Highway 2 will have a significant impact on traffic into and through the City of Devils Lake.
- Feature 8: Rural Areas – Feature 13 is a major connection for surrounding rural areas. Decisions on road raises will impact land and infrastructure throughout these areas.

- Feature14: ND Highway 57 (between ND Highway 20 and BIA 1) – Feature 14 terminates at the north just south of the City of Devils Lake (near the intersection with US Highway 2). Closure or relocation of Feature 14 will cut off access to US Highway 2 from the southwest, therefore decreasing traffic on US Highway 2. Similarly, closure of US Highway 2 would impact traffic going southwest on Feature 14.
- Feature 15: ND Highway 57 (between BIA 1 and US Highway 281) – This portion of Highway 57 runs east-west along the south shore of Devils Lake. If US Highway 2 is closed, some traffic could be diverted to Feature 15 and cause increased traffic there (and vice-versa).
- Feature 16: US Highway 281 (South of US Highway 2) – Feature 16 connects with US Highway 2 at the northerly end near Churchs Ferry, and is the main route of travel from the Minnewaukan area to Churchs Ferry. Closure or relocation of Feature 16 will impact the amount of travel that reaches US Highway 2 depending on the protection strategy chosen. Similarly, closure of US Highway 2 will impact the amount of traffic that flows north-south on US Highway 281.
- Feature 18: ND Highway 19 – Feature 18 meets US Highway 2 in the City of Devils Lake. If travel on Feature 18 is altered due to implementation of a protection strategy, it will increase traffic on Feature 13, and vice-versa, mostly with respect to east-west travel.
- Feature 20: ND Highway 20 (North of the City of Devils Lake) – Feature 20 intersects US Highway 2 near the City of Devils Lake. If US Highway 2 is closed, Feature 20 could experience increased traffic as a detour route, and vice-versa, depending on the protection strategy implemented.
- Feature 22: ND Highway 20 (ND Highway 57 to Tokio) – Feature 22 is a major north-south route on the Spirit Lake Nation Reservation that connects the eastern portion of the reservation to US Highway 2. If US Highway 2 is closed, traffic on Feature 22 would be impacted, mostly due to decreased traffic from the north entering Devils Lake (and vice-versa).
- Feature 24: BIA Highway 6 – This portion of Highway 6 runs east-west to the south of US Highway 2. If US Highway 2 is closed, traffic could be diverted to Feature 24 and cause increased traffic there (and vice-versa).

Table 2.0-1, mentioned earlier in this report, provides a summary of the interdependencies among the features.

2.13.3 Feature Economics

Damages: For US Highway 2, the damages resulting from flooding were estimated up to the maximum lake level (1463). The damage computations for Feature 13 are summarized in the accompanying Table 2.13-1.

Table 2.13-1 lists annual detour damages and restoration damage costs. Annual detour damages represent the cost of increased use on other roads while US Highway 2 is temporarily closed. Restoration damages represent the costs to restore US Highway 2 once the lake levels recede after a period of flooding. Restoration damages include rebuilding the road with excavation, fill, surface material, and bridge repairs. Restoration damages are a per-event damage.

Unit costs for all the damage computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for US Highway 2 are listed in the Feature 13 Assumptions listing, appended to this Section 2.13.

Costs: The costs of providing flood protection for US Highway 2 are detailed in the accompanying Table 2.13-2. Unit costs, data sources, and relevant assumptions are listed.

Table 2.13-2 lists unit costs of incremental road raises and relocation costs. Incremental road raise costs are broken down into six categories: fabric liner, aggregate base, fill, riprap, bituminous, and bridge work.

Unit costs for all the cost computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for US Highway 2 are listed in the Feature 13 Assumptions listing, appended to this Section 2.13.

2.13.4 Results of Economic Analysis

The results of the Economic Analysis for the US Highway 2 are listed in Table 2.13-3.

Stochastic Analysis Results: The stochastic analysis indicated that the annual net benefits for incremental road raises on US Highway 2 were greater than zero ($81,400). This strategy is highlighted on the decision tree (Figure 2.13-2). The BCR for this strategy was greater than one (1.14). These results indicate that this strategy was economically justified. The present worth annualized detour damages that would be prevented by this strategy were computed to be $629,100. The stochastic results are averages over 10,000 traces.

Results for Specific Scenarios: In the economic analysis, flood protection strategies were also analyzed for three specific climate futures. For US Highway 2, the identified strategy and the economic indices for each of the three climate futures are as follows:

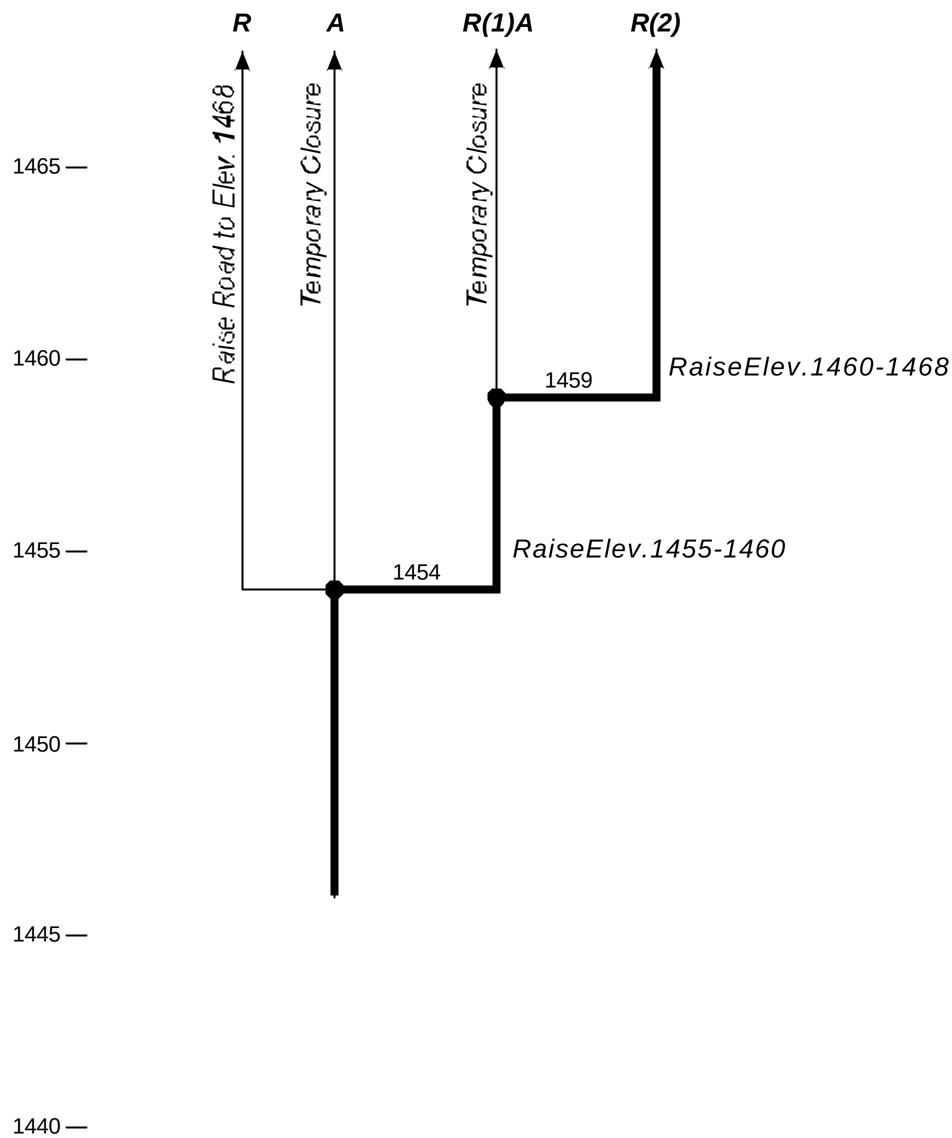
- Wet Future – For the wet future, the annual net benefits were predicted to be $2,176,000, and the BCR was 1.44, indicating that this strategy was economically justified. For this future, the present worth annualized detour damages that would be prevented were computed at $6,895,400.

- First Moderate Future – For the first moderate future, lake levels do not reach first damage levels.

- Second Moderate Future – For the second moderate future, the strategy with the largest net benefits was shown to be two incremental road raises. For this strategy, the net benefits were $98,200, and the BCR was 1.06, indicating that this strategy was economically justified. For this future, the present worth annualized detour damages that would be prevented were computed at $1,573,700.

DATA: 1997 USGS Digital Ortho Quad.

Barr: Arcview 3.1, PIIIAF, I:\Client\DevilsLake\Gis\DLIP\Features\RoadandRails\Roads\13_USHwy2\Project\basemap_13.apr, Layout: Layout: Section 2 figure, lkp, Wed Oct 30 12:31:01 2002



LowestRoadElevation:1455

P:\34\36\1020\DECISIONTREES\2002FIGURES\FIGURE2_13.CDR RLG 01-02-03

▬	FloodProtectionStrategy
●	Decisionrequiredatthispoint
⊙	Triggerpointforaction,nodecisionneeded
R(1)	Incrementalroad raise(number oftimes)
R	Road raiseto1468
A	Temporary closureofroad

Figure2.13-2

DECISION TREE
FEATURE 13:U.S.HIGHWAY2
DevilsLakeInfrastructure ProtectionStudy

Table 2.13-1

Flood Damages
Feature 13: US Highway 2
Devils Lake Infrastructure Protection Study

DAMAGES

Action Levels	Annual Detour Damages
	(THOUSANDS)
AL1 - AL2	$11,863

DAMAGE BREAKDOWN

Damage	AL1 - AL2				
	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Annual Detour Damages	US Highway 2				
	HR/YEAR	482,229	HR	$7.00	$3,376
	MILES/YEAR	26,522,615	MILE	$0.32	$8,487
	Total				**$11,863**

Restoration Damages

Elevation	Total (THOUSANDS)	Excavation Quantity	Excavation Units	Excavation Unit Cost	Excavation Value (THOUSANDS)	Fabric Liner Quantity	Fabric Liner Units	Fabric Liner Unit Cost	Fabric Liner Value (THOUSANDS)	Aggregate Base Course Quantity	Aggregate Base Course Units	Aggregate Base Course Unit Cost	Aggregate Base Course Value (THOUSANDS)	Fill Quantity	Fill Units	Fill Unit Cost	Fill Value (THOUSANDS)	Bituminous Pavement Quantity	Bituminous Pavement Units	Bituminous Pavement Unit Cost	Bituminous Pavement Value (THOUSANDS)	Bridge Repair Quantity	Bridge Repair Units	Bridge Repair Unit Cost	Bridge Repair Cost (THOUSANDS)
1454	$0																								
1455	$1,679	46,800	CY	$2.65	$124	82,887	SY	$1.33	$110	10,075	CY	$21.20	$214	69,292	CY	$4.77	$331	18,876	TON	$47.70	$900	0	EA	$530,000	$0
1456	$1,679	46,800	CY	$2.65	$124	82,887	SY	$1.33	$110	10,075	CY	$21.20	$214	69,292	CY	$4.77	$331	18,876	TON	$47.70	$900	0	EA	$530,000	$0
1457	$11,830	329,800	CY	$2.65	$874	584,107	SY	$1.33	$777	70,999	CY	$21.20	$1,505	488,305	CY	$4.77	$2,329	133,019	TON	$47.70	$6,345	0	EA	$530,000	$0
1458	$14,097	393,000	CY	$2.65	$1,041	696,040	SY	$1.33	$926	84,604	CY	$21.20	$1,794	581,879	CY	$4.77	$2,776	158,510	TON	$47.70	$7,561	0	EA	$530,000	$0
1459	$16,823	469,000	CY	$2.65	$1,243	830,644	SY	$1.33	$1,105	100,965	CY	$21.20	$2,140	694,405	CY	$4.77	$3,312	189,163	TON	$47.70	$9,023	0	EA	$530,000	$0
1460	$16,823	469,000	CY	$2.65	$1,243	830,644	SY	$1.33	$1,105	100,965	CY	$21.20	$2,140	694,405	CY	$4.77	$3,312	189,163	TON	$47.70	$9,023	0	EA	$530,000	$0
1461	$18,330	511,000	CY	$2.65	$1,354	905,029	SY	$1.33	$1,204	110,007	CY	$21.20	$2,332	756,591	CY	$4.77	$3,609	206,103	TON	$47.70	$9,831	0	EA	$530,000	$0
1462	$20,323	537,000	CY	$2.65	$1,423	951,077	SY	$1.33	$1,265	115,604	CY	$21.20	$2,451	795,087	CY	$4.77	$3,793	216,590	TON	$47.70	$10,331	2	EA	$530,000	$1,060
1463	$22,260	591,000	CY	$2.65	$1,566	1,046,729	SY	$1.33	$1,392	127,229	CY	$21.20	$2,697	875,039	CY	$4.77	$4,174	238,370	TON	$47.70	$11,370	2	EA	$530,000	$1,060

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.

Table 2.13-2

Flood Protection Costs
Feature 13: US Highway 2
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Action Level	Lake Elevation	R Maximum Raise at AL1	A Temporary Closure at AL1	R(1)A Raise at AL1; Temporary Closure at AL2	R(2) Raise at AL1, AL2
	(MSL)	(THOUSANDS)			
AL1	1454	$152,738	$0	$50,648	$50,648
AL2	1459	$0	$0	$0	$102,090

COST BREAKDOWN

		R									
		R(1)A									
		R(2)					R(2)				
		Lake Elevation 1454					Lake Elevation 1459				
Strategy		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Incremental Raise											
	Road Raise	US Highway 2					US Highway 2				
		Fabric Liner	1,091,785	SY	$1.33	$1,452	Fabric Liner	1,562,191	SY	$1.33	$2,078
		Aggregate Base	100,965	CY	$21.20	$2,140	Aggregate Base	38,922	CY	$21.20	$825
		Fill	1,790,448	CY	$9.00	$16,114	Fill	7,031,904	CY	$9.00	$63,287
		Riprap	730,603	CY	$30.00	$21,918	Riprap	1,045,390	CY	$30.00	$31,362
		Bituminous	189,163	TON	$47.70	$9,023	Bituminous	72,923	TON	$47.70	$3,478
		Bridge Rebuild	0	EA	$530,000	$0	Bridge Rebuild	2	EA	$530,000	$1,060
		Total				**$50,648**	**Total**				**$102,090**

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. The costs for the Maximum Raise at AL1 strategy (R) is equal to the sum of the costs for all incremental raises.

Table 2.13 - 3

Economic Analysis of Strategies for US Highway 2 (Feature 13)

Strategy		Stochastic Analysis (ST) Mean Value over 10,000 Traces (Annual)									
		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Le	$0	$0	$0	$37,300	$629,100	$0	$666,400	$0	$0	--
R	Road Raise to 1468	########	$0	$1,047,700	$0	$0	$0	$0	$666,400	-$381,200	0.64
R(1)A	1 Road Raise: Then Temporary Closure During Flo	$347,400	$0	$347,400	$34,900	$147,400	$0	$182,300	$484,200	$136,700	1.39
R(2)	2 Incr. Road Raises	$585,100	$0	$585,100	$0	$0	$0	$0	$666,400	$81,400	1.14

Strategy		Wet Future Scenario (WF) (Annual)									
		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Le	$0	$0	$0	$214,100	########	$0	$7,109,600	$0	$0	--
R	Road Raise to 1468	########	$0	$6,222,100	$0	$0	$0	$0	$7,109,600	$887,500	1.14
R(1)A	1 Road Raise: Then Temporary Closure During Flo	########	$0	$2,063,200	$252,500	########	$0	$3,166,900	$3,942,600	$1,879,400	1.91
R(2)	2 Incr. Road Raises	########	$0	$4,933,600	$0	$0	$0	$0	$7,109,600	$2,176,000	1.44

Strategy		Moderate Future 1 Scenario (M1) (Annual)									
		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Le	$0	$0	$0	$0	$0	$0	$0	$0	$0	--
R	Road Raise to 1468	$0	$0	$0	$0	$0	$0	$0	$0	$0	--
R(1)A	1 Road Raise: Then Temporary Closure During Flo	$0	$0	$0	$0	$0	$0	$0	$0	$0	--
R(2)	2 Incr. Road Raises	$0	$0	$0	$0	$0	$0	$0	$0	$0	--

Strategy		Moderate Future 2 Scenario (M2) (Annual)									
		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Le	$0	$0	$0	$39,200	########	$0	$1,613,000	$0	$0	--
R	Road Raise to 1468	########	$0	$4,568,100	$0	$0	$0	$0	$1,613,000	-$2,955,100	0.35
R(1)A	1 Road Raise: Then Temporary Closure During Flo	########	$0	$1,514,800	$0	$0	$0	$0	$1,613,000	$98,200	1.06
R(2)	2 Incr. Road Raises	########	$0	$1,514,800	$0	$0	$0	$0	$1,613,000	$98,200	1.06

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.375% and rounded to the nearest $100.
* Total benefits are calculated as the total damages incurred for "temporary closure strategy" minus the total damages for the strategy implemented (G(S)).
The "No Protection" strategy for roads has been defined as temporary closure during floods at the first action level with restoration when the lake recedes.
The top action level (1463) is never reached in the 10,000 traces, rendering some of the costs and damages equal between different strategies.

Attachment to 2.13:
US Highway 2 Economic Analysis Assumptions

1. Plans for 2001 include raising Highway 2 from a minimum elevation of 1454 to 1455 and the bridges at Mauvais Coulee and Channel A from 1452 to 1461 (low chord). For this analysis, the work was assumed completed and the new elevations were used.

A. General Assumptions

1. Decisions were assumed to occur when the lake level is within (or predicted by the National Weather Service to be within) 1 foot of the lowest road elevation. This assumption is consistent with current practices in the area as dictated by funding agencies. In the past, funding for road raises has not been available until the National Weather Service predicts on February 15th that the road will go under water during that year.

2. If the road includes a bridge having a low chord elevation below the lowest road elevation, it was assumed that no decision would occur until the lake level was within 1 foot of the lowest road elevation. This assumption follows current practices in the area.

B. Road Raises

1. Road raise costs were calculated in the manner presented in a previous study (*Devils Lake Flood Control: Economics Database Update: Transportation Report,* Barr Engineering Company, January 1998). Unit costs for construction materials were updated for inflation by multiplying them by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001. Additionally the cost of riprap and fill were increased from $20 to $30 and $4.50 to $9.00, respectively. Based on conversations with the NDDOT, railroad companies, and the Corps of Engineers the new costs for riprap and fill are more representative of the costs in the area.

2. The last road raise was assumed to be to elevation 1468. At this elevation, roads would be 5 feet above the assumed maximum lake level (elevation 1463).

3. The final incremental road raise (to elevation 1468) was assumed to be no more than 8 feet and no less than 4 feet.

C. Temporary Road Closure During Floods

1. It was assumed that if a road was temporarily closed, it would be restored after the lake level has receded 1 foot below the top of road. All of the road features in this study are highly traveled. It is very likely that people would want to use these roads again if the lake level receded after flooding, assuming that communities, businesses, farmsteads, and residents continue to generate the same level of traffic as at present.

2. Restoration damages were calculated in the manner presented in *Devils Lake Flood Control: Economics Database Update: Transportation Report,* Barr Engineering Company, January 1998. Unit costs for construction materials were updated for inflation by multiplying them by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001.

3. Detour damages were included for every year that a road is temporarily closed, as well as for the first year that the lake has receded. It was assumed that during the first year after the lake has receded, the road would be under restoration. During this first year, there would be both a detour damage and restoration damage. After this first year, there would be no further detour or restoration damages unless the lake rises to within 1 foot of the road again.

4. Restoration of a road would only occur after the lake has receded to 1 foot below the lowest elevation in that road. This was based on the assumption that restoration would only occur when there is no water on any part of the road and there would be only minor potential for wave action damage on the road.

5. Detour damages were calculated using a cost of $7 per hour of additional travel time, 1.5 people per vehicle, and $0.32 per mile for additional travel distance (Corps of Engineers, March, 2001). Additional time and miles traveled were taken from the results of the QRS II model used in *Devils Lake Flood Control: Economics Database Update: Transportation Report,* Barr Engineering Company, January 1998. The QRS II model determines the overall effect of a closed road on an entire network of traffic, incorporating the fact that traffic consists of trips having different origins and destinations.

6. Detour paths were determined assuming that all other featured roads would be open. No effort was made to link detour routes with lake level.

D. Road Reroutes

1. This feature has no logical reroute.

2.14 Summary of Economic Analysis Investigation for Feature 14: ND Highway 57 (between ND Highway 20 and BIA Highway 1)

2.14.0 Flood Protection Strategy

The flood protection strategy that was analyzed in the Economic Analysis of Devils Lake Alternatives for ND Highway 57 (between ND Highway 20 and BIA Highway 1) was incremental road raises.

2.14.1 General Information

Feature Type: Road

Location: ND Highway 57 (between ND Highway 20 and BIA Highway 1) is located in the Third Commissioner District Township, Benson County and on the Spirit Lake Nation Reservation. The feature extends approximately 3.5 miles from ND Highway 20 at the north to BIA Highway 1 to the south. The accompanying Figure 2.14-1 shows the feature's location and extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: ND Highway 57 (between ND Highway 20 and BIA Highway 1) is a two-lane bituminous-surfaced state highway. The centerline elevation is at 1455 over the entire feature, except the bridge and its approaches. The bridge road surface elevation is 1465.

Significance: ND Highway 57 (between ND Highway 20 and BIA Highway 1) is important because it is the major north/south arterial route through the Devils Lake region between Fort Totten, St. Michael and the City of Devils Lake. The ND Highway 57 bridge spans the most restricted section of land around Devils Lake, sometimes called the "Narrows."

Damages: The flooding of ND Highway 57 (between ND Highway 20 and BIA Highway 1) would result in the following damages:

- Detour damages resulting from the added travel time and miles traveled when the highway is closed and traffic is detoured.
- Restoration damages resulting from repairs that would be necessary to bring the highway back to a useable condition after a period of inundation.

Owner/Sponsor: The North Dakota Department of Transportation is responsible for managing and maintaining ND Highway 57.

Lead Federal Agency: The Federal Highway Administration would take the lead for ND Highway 57 in any flood protection work that may take place.

2.14.2 Feature Protection

History of Flood Protection: In the past, flood protection for ND Highway 57 (between ND Highway 20 and BIA Highway 1) has consisted of raising the road to keep it from being overtopped. The most recent raise of ND Highway 57 occurred in 1999 when the road was raised to a minimum of 1455 for the entire length of this feature. The bridge over the Narrows was also reconstructed in 1999, with a minimum deck at 1465. A previous raise was completed in 1997 when 0.74 miles of the road was raised to 1447.5.

General Protection Strategy: The analysis identified and evaluated one approach for protecting ND Highway 57 (between ND Highway 20 and BIA Highway 1): raising the road.

Protection Strategy by Lake Level: The Economic Analysis of Devils Lake Alternatives analyzed the flood protection strategy of raising the road, with flood protection decisions being made at various lake levels as Devils Lake continued to rise. Figure 2.14-2 shows the decision tree for ND Highway 57 (between ND Highway 20 and BIA Highway 1). As shown on Figure 2.14-2, the stepwise approach to flood protection for ND Highway 57 (between ND Highway 20 and BIA Highway 1) that was analyzed consisted of the following:

1. At lake elevation 1454, a decision would be made as to whether the road would be raised to 1460, or temporarily closed.

2. If the road were raised at the first action level, at lake elevation 1459 another decision would be made as to whether the road would be raised to 1468, or temporarily closed.

The maximum protection strategy that was analyzed at the first action level was raising the road to 1468. (Note that for the analysis, the decision regarding whether or not to raise the road is made at a time when the lake is one foot below the minimum highway elevation that resulted from the most recent raise.)

Interdependencies: The protection of ND Highway 57 (between ND Highway 20 and BIA Highway 1) is related to the protection of several other features:

- Feature 3: Fort Totten – Roads closed or rerouted in Fort Totten could result in decreased traffic loads for ND Highway 57 (between ND Highway 20 and BIA Highway 1) and vice versa. Therefore, it is necessary to make decisions regarding flood protection in Fort Totten in conjunction with deciding upon a strategy for ND Highway 57 (between ND Highway 20 and BIA Highway 1).

- Feature 13: US Highway 2 – ND Highway 57 (between ND Highway 20 and BIA Highway 1) terminates just south of the City of Devils Lake (near the intersection with US Highway 2).

Closure or relocation of Feature 14 could cut off access to Feature 13 from the southwest, therefore decreasing traffic on US Highway 2 (and vice versa).

- Feature 15: ND Highway 57 (between BIA Highway 1 and US Highway 281) – If ND Highway 57 (between ND Highway 20 and BIA Highway 1) is temporarily closed, Feature 15 is impacted because its eastern terminus is at its junction with Feature 14.
- Feature 16: US Highway 281 (South of US Highway 2) – Closure or relocation of Feature 16 will increase the amount of travel that reaches Feature 14 because it would serve as an alternate north-south route through the Spirit Lake Nation Reservation.
- Feature 18: ND Highway 19 – Closure or relocation of Feature 18 will impact the amount of traffic on Feature 14 (and vise-versa) because the two features are alternate east-west travel routes.
- Feature 24: BIA Highway 6 – Closure or relocation of Feature 24 will impact the amount of traffic on Feature 14 (and vise-versa) because the two features are alternate east-west travel routes through the Spirit Lake Nation Reservation.

Table 2.0-1, mentioned earlier in this report, provides a summary of the interdependencies among the features.

2.14.3 Feature Economics

Damages: For ND Highway 57 (between ND Highway 20 and BIA Highway 1), the damages resulting from flooding were estimated up to the maximum lake level (1463). The damage computations for ND Highway 57 (between ND Highway 20 and BIA Highway 1) are summarized in the accompanying Table 2.14-1.

The detour damages for ND Highway 57 (between ND Highway 20 and BIA Highway 1) assume that all other features are open, and traffic is routed around the lake if ND Highway 57 (between ND Highway 20 and BIA Highway 1) is temporarily closed. This was one of the four features in the Economics Analysis that was credited with the large detour damages around the lake (See discussion in Section 2.0.1.5). The computation of basin-wide damages required certain assumptions regarding interdependent roads in order to ensure that the basin-wide Economic Analysis was accurately representing overall traffic patterns.

The top portion of Table 2.14-1 gives a summary of the annual detour damages that would occur during the years when the highway was flooded. It also shows road restoration damages that can be expected to restore this road when the lake recedes after a period of flooding. Restoration damages include rebuilding the road with excavation, fill, surface material, and bridge repairs. Restoration damages are a per-event damage.

The lower portion of the table shows the breakdown of these summary values for each of the action levels. It gives quantities in terms of miles per year (of extra miles traveled as a result of detours) and hours per year (of additional travel time resulting from detours) for the detour damages. Also shown are quantities and line-item damages for excavation, fabric liner, aggregate base course, and fill for road restoration work when waters recede.

Unit prices for all the damage computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for ND Highway 57 (between ND Highway 20 and BIA Highway 1) are listed in the Feature 14 Assumptions listing, appended to this Section 2.14.

Costs: The costs of providing flood protection for ND Highway 57 (between ND Highway 20 and BIA Highway 1) are detailed in the accompanying Table 2.14-2 for ND Highway 57 (between ND Highway 20 and BIA Highway 1). Quantities and line-item totals are listed.

The top portion of the table gives the costs of providing flood protection (as represented in the analysis) by action level for various levels of flood protection. The lower portion of the table gives a breakdown of the quantities and costs by line item: fabric liner, aggregate base, fill, riprap, and bituminous pavement material.

Unit costs for all the cost computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for ND Highway 57 (between ND Highway 20 and BIA Highway 1) are listed in the ND Highway 57 (between ND Highway 20 and BIA Highway 1) Assumptions listing, appended to this Section 2.14.

2.14.4 Results of Economic Analysis

The results of the Economic Analysis for the ND Highway 57 (between ND Highway 20 and BIA Highway 1) are listed in Table 2.14-3.

Stochastic Analysis Results: The stochastic analysis indicated that the annual net benefits for incremental road raises on ND Highway 57 (between ND Highway 20 and BIA Highway 1) were greater than zero ($641,600). This strategy is highlighted on the decision tree (Figure 2.14-2). The BCR for this approach was greater than one (11.47). These results indicate that this strategy was economically justified. The present worth annualized detour damages that would be prevented by this strategy were computed to be $694,900. The stochastic results are averages over 10,000 traces.

Results for Specific Scenarios: In the economic analysis, flood protection strategies were also analyzed for three specific climate futures. For ND Highway 57 (between ND Highway 20 and

BIA Highway 1), the identified strategy and the economic indices for each of the three climate futures are as follows:

- Wet Future – For the wet future, annual net benefits were $7,159,200, and the BCR was 15.93, indicating that this strategy was economically justified. For this future, the present worth annualized detour damages that would be prevented were computed at $7,616,700.
- First Moderate Future – For the first moderate future, lake levels do not reach first damage levels.
- Second Moderate Future – For the second moderate future, the net benefits were $1,592,400, and the BCR was 9.58, indicating that this strategy was economically justified. For this future, the present worth annualized detour damages that would be prevented were computed at $1,738,400.

Figure 2.14-1
LOCATION MAP
FEATURE 14: ND HIGHWAY 57
(BETWEEN ND HIGHWAY 20
AND BIA HIGHWAY 1)
Devils Lake Infrastructure
Protection Study

DATA: 1997 USGS Digital Ortho Quad

Barr: Arcview 3.1, OPT2615, I:\Client\DevilsLake\Gis\DLIP\Features\RoadandRails\Roads\14_Hwy57_20_1\Project\basemap_14.apr, Layout: Layout: Section 2 Hwy 57, lkp, Thu Jan 02 09:54:10 2003

Table 2.14-2

Flood Protection Costs
Feature 14: ND Highway 57 (between ND Highway 20 and BIA Highway 1)
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Action Level	Lake Elevation	R Maximum Raise at AL1	A Temporary Closure at AL1	R(1)A Raise at AL1; Temporary Closure at AL2	R(2) Raise at AL1, AL2
	(MSL)	(THOUSANDS)			
AL1	1454	$14,274	$0	$6,203	$6,203
AL2	1459	$0	$0	$0	$8,071

COST BREAKDOWN

		R									
		R(1)A									
		R(2)					R(2)				
		Lake Elevation 1454					Lake Elevation 1459				
Strategy		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Incremental Raise											
	Road Raise	ND Highway 57					ND Highway 57				
		Fabric Liner	127,980	SY	$1.33	$170	Fabric Liner	106,564	SY	$1.33	$142
		Aggregate Base	10,161	CY	$21.20	$215	Aggregate Base	0	CY	$21.20	$0
		Fill	260,037	CY	$9.00	$2,340	Fill	643,319	CY	$9.00	$5,790
		Riprap	85,642	CY	$30.00	$2,569	Riprap	71,311	CY	$30.00	$2,139
		Bituminous	19,037	TON	$47.70	$908	Bituminous	0	TON	$47.70	$0
		Bridge Rebuild	0	EA	$530,000	$0	Bridge Rebuild	0	EA	$530,000	$0
		Total				**$6,203**	**Total**				**$8,071**

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. The costs for the Maximum Raise at AL1 strategy (R) is equal to the sum of the costs for all incremental raises.

Table 2.14-2

Flood Protection Costs
Feature 14: ND Highway 57 (between ND Highway 20 and BIA Highway 1)
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Action Level	Lake Elevation	R Maximum Raise at AL1	A Temporary Closure at AL1	R(1)A Raise at AL1; Temporary Closure at AL2	R(2) Raise at AL1, AL2
	(MSL)	(THOUSANDS)			
AL1	1454	$14,274	$0	$6,203	$6,203
AL2	1459	$0	$0	$0	$8,071

COST BREAKDOWN

		R									
		R(1)A									
		R(2)					R(2)				
		Lake Elevation 1454					Lake Elevation 1459				
Strategy		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Incremental Raise											
	Road Raise	ND Highway 57					ND Highway 57				
		Fabric Liner	127,980	SY	$1.33	$170	Fabric Liner	106,564	SY	$1.33	$142
		Aggregate Base	10,161	CY	$21.20	$215	Aggregate Base	0	CY	$21.20	$0
		Fill	260,037	CY	$9.00	$2,340	Fill	643,319	CY	$9.00	$5,790
		Riprap	85,642	CY	$30.00	$2,569	Riprap	71,311	CY	$30.00	$2,139
		Bituminous	19,037	TON	$47.70	$908	Bituminous	0	TON	$47.70	$0
		Bridge Rebuild	0	EA	$530,000	$0	Bridge Rebuild	0	EA	$530,000	$0
		Total				**$6,203**	**Total**				**$8,071**

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. The costs for the Maximum Raise at AL1 strategy (R) is equal to the sum of the costs for all incremental raises.

Table 2.14 - 3

Economic Analysis of Strategies for
Highway 57 between Highway 20 and BIA 1
(Feature 14)

Stochastic Analysis (ST) — Mean Value over 10,000 Traces (Annual)

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Relocation	Total	Restoration	Detour	Relocation Detour	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C = A + B	D	E	F	G = D + E + F	H = G(A) - G(S) *	I = H - C	I = H / C
A	Temporary Closure During Floods at First Action Le	$0	$0	$0	$8,100	$694,900	$0	$703,000	$0	$0	--
R	Road Raise to 1468	$97,900	$0	$97,900	$0	$0	$0	$0	$703,000	$605,000	7.18
R(1)A	1 Road Raise: Then Temporary Closure During Flo	$42,500	$0	$42,500	$3,300	$162,800	$0	$166,100	$536,800	$494,300	12.63
R(2)	2 Incr. Road Raises	$61,300	$0	$61,300	$0	$0	$0	$0	$703,000	$641,600	11.47

Wet Future Scenario (WF) (Annual)

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Relocation	Total	Restoration	Detour	Relocation Detour	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C = A + B	D	E	F	G = D + E + F	H = G(A) - G(S) *	I = H - C	I = H / C
A	Temporary Closure During Floods at First Action Le	$0	$0	$0	$22,100	########	$0	$7,638,900	$0	$0	--
R	Road Raise to 1468	#######	$0	$581,500	$0	$0	$0	$0	$7,638,900	$7,057,400	13.14
R(1)A	1 Road Raise: Then Temporary Closure During Flo	#######	$0	$252,700	$24,100	########	$0	$3,243,400	$4,395,400	$4,142,800	17.39
R(2)	2 Incr. Road Raises	#######	$0	$479,600	$0	$0	$0	$0	$7,638,900	$7,159,200	15.93

Moderate Future 1 Scenario (M1) (Annual)

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Relocation	Total	Restoration	Detour	Relocation Detour	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C = A + B	D	E	F	G = D + E + F	H = G(A) - G(S) *	I = H - C	I = H / C
A	Temporary Closure During Floods at First Action Le	$0	$0	$0	$0	$0	$0	$0	$0	$0	--
R	Road Raise to 1468	$0	$0	$0	$0	$0	$0	$0	$0	$0	--
R(1)A	1 Road Raise: Then Temporary Closure During Flo	$0	$0	$0	$0	$0	$0	$0	$0	$0	--
R(2)	2 Incr. Road Raises	$0	$0	$0	$0	$0	$0	$0	$0	$0	--

Moderate Future 2 Scenario (M2) (Annual)

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Relocation	Total	Restoration	Detour	Relocation Detour	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C = A + B	D	E	F	G = D + E + F	H = G(A) - G(S) *	I = H - C	I = H / C
A	Temporary Closure During Floods at First Action Le	$0	$0	$0	$39,500	########	$0	$1,777,900	$0	$0	--
R	Road Raise to 1468	#######	$0	$426,900	$0	$0	$0	$0	$1,777,900	$1,351,000	4.16
R(1)A	1 Road Raise: Then Temporary Closure During Flo	#######	$0	$185,500	$0	$0	$0	$0	$1,777,900	$1,592,400	9.58
R(2)	2 Incr. Road Raises	#######	$0	$185,500	$0	$0	$0	$0	$1,777,900	$1,592,400	9.58

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.375% and rounded to the nearest $100.
* Total benefits are calculated as the total damages incurred for "temporary closure strategy" minus the total damages for the strategy implemented (G(S)).
The "No Protection" strategy for roads has been defined as temporary closure during floods at the first action level with restoration when the lake recedes.

Attachment to 2.14:
ND Highway 57 (between ND Highway 20 and BIA Highway 1) Economic Analysis Assumptions

No feature-specific assumptions were made for Feature 14.

A. General Assumptions

1. Decisions were assumed to occur when the lake level is within (or predicted by the National Weather Service to be within) 1 foot of the lowest road elevation. This assumption is consistent with current practices in the area as dictated by funding agencies. In the past, funding for road raises has not been available until the National Weather Service predicts on February 15th that the road will go under water during that year.

2. If the road includes a bridge having a low chord elevation below the lowest road elevation, it was assumed that no decision would occur until the lake level was within 1 foot of the lowest road elevation. This assumption follows current practices in the area.

B. Road Raises

1. Road raise costs were calculated in the manner presented in a previous study (*Devils Lake Flood Control: Economics Database Update: Transportation Report*, Barr Engineering Company, January 1998). Unit costs for construction materials were updated for inflation by multiplying them by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001. Additionally the cost of riprap and fill were increased from $20 to $30 and $4.50 to $9.00, respectively. Based on conversations with the NDDOT, railroad companies, and the Corps of Engineers the new costs for riprap and fill are more representative of the costs in the area.

2. The last road raise was assumed to be to elevation 1468. At this elevation, roads would be 5 feet above the assumed maximum lake level (elevation 1463).

3. The final incremental road raise (to elevation 1468) was assumed to be no more than 8 feet and no less than 4 feet.

4. Bureau of Indian Affairs (BIA) roads were assumed to be raised in 5-foot increments (*Devils Lake Flood Control: Economics Database Update: Transportation Report*, Barr Engineering Company, January 1998).

C. Temporary Road Closure During Floods

1. It was assumed that if a road was temporarily closed, it would be restored after the lake level has receded 1 foot below the top of road. All of the road features in this study are highly traveled. It is very likely that people would want to use these roads again if the lake level receded after flooding.

assuming that communities, businesses, farmsteads, and residents continue to generate the same level of traffic as at present.

2. Restoration damages were calculated in the manner presented in *Devils Lake Flood Control: Economics Database Update: Transportation Report*, Barr Engineering Company, January 1998. Unit costs for construction materials were updated for inflation by multiplying them by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001.

3. Detour damages were included for every year that a road is temporarily closed, as well as for the first year that the lake has receded. It was assumed that during the first year after the lake has receded, the road would be under restoration. During this first year, there would be both a detour damage and restoration damage. After this first year, there would be no further detour or restoration damages unless the lake rises to within 1 foot of the road again.

4. Restoration of a road would only occur after the lake has receded to 1 foot below the lowest elevation in that road. This was based on the assumption that restoration would only occur when there is no water on any part of the road and there would be only minor potential for wave action damage on the road.

5. Detour damages were calculated using a cost of $7 per hour of additional travel time, 1.5 people per vehicle, and $0.32 per mile for additional travel distance (Corps of Engineers, March, 2001). Additional time and miles traveled were taken from the results of the QRS II model used in *Devils Lake Flood Control: Economics Database Update: Transportation Report*, Barr Engineering Company, January 1998. The QRS II model determines the overall effect of a closed road on an entire network of traffic, incorporating the fact that traffic consists of trips having different origins and destinations.

6. There is more commitment on the part of the North Dakota Department of Transportation (NDDOT) to the Highway 57 causeway than to the Highway 20 causeway through The Narrows. Therefore, Highway 57 was assumed to be the detour route for the Highway 20 causeway. If the Highway 57 causeway was temporarily closed during flooding, it was assumed that the Highway 20 causeway would also be temporarily closed.

7. The detour route for Highway 57 is around the lake to the west via Highway 281 and Highway 19. Woods-Rutten Road was considered as a detour route for Highway 57, but it was not retained as a viable alternative, because it would have to be significantly raised and improved to carry the traffic of Highway 57.

8. Detour paths for this feature were determined assuming that Highway 20 across The Narrows is closed. No effort was made to link detour routes with lake level.

9. Two features can have mutually interdependent detour routes if they are the most reasonable detours. In these cases, it was assumed that either the analyzed feature or the other feature would be raised or rerouted. In these cases, the interdependency was noted.

D. Road Reroutes

1. There was no logical reroute for this feature.

2.15 Summary of Economic Analysis Investigation for Feature 15: ND Highway 57 (between BIA Highway 1 and US Highway 281)

2.15.0 Flood Protection Strategy

The flood protection strategy that was analyzed in the Economic Analysis of Devils Lake Alternatives for ND Highway 57 (between BIA Highway 1 and US Highway 281) was incremental road raises.

2.15.1 General Information

Feature Type: Road

Location: ND Highway 57 (between BIA Highway 1 and US Highway 281) is located in the Third Commissioner District, Lallie East and Lallie West Townships in Benson County, on the Spirit Lake Nation Reservation. The feature extends approximately 9 miles between US Highway 281 at the west to BIA Highway 1 at the east. The accompanying Figure 2.15-1 shows the feature's location and extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: ND Highway 57 (between BIA Highway 1 and US Highway 281) is a two-lane bituminous-surfaced state highway. The centerline elevation is 1455 from BIA 1 to Ski Jump Road, while the remaining road elevation varies, most of it being above elevation 1450. Those portions of this feature below 1455 are planned to be raised to 1455 in 2002, according to ND DOT sources.

Significance: ND Highway 57 (between BIA Highway 1 and US Highway 281) is important because it is the major east/west arterial route through the Spirit Lake Nation Reservation and provides the most direct route between the City of Devils Lake and Fort Totten. One small section of the roadway (just south of BIA Highway 1) is currently acting as a dam (see analysis of Feature 25).

Damages: The flooding of ND Highway 57 (between BIA Highway 1 and US Highway 281) would result in the following damages:

- Detour damages resulting from the added travel time and miles traveled when ND Highway 57 (between BIA Highway 1 and US Highway 281) is closed and traffic is detoured
- Restoration damages resulting from repairs that would be necessary to bring the highway back to a useable condition after a period of inundation

Owner/Sponsor: The North Dakota Department of Transportation is responsible for managing and maintaining ND Highway 57 (between BIA Highway 1 and US Highway 281).

Lead Federal Agency: The Federal Highway Administration would take the lead for ND Highway 57 (between BIA Highway 1 and US Highway 281) in any flood protection work that may take place.

2.15.2 Feature Protection

History of Flood Protection: In the past, flood protection for ND Highway 57 (between BIA Highway 1 and US Highway 281) has consisted of raising the road to keep it from being overtopped. The most recent raise of ND Highway 57 (between BIA Highway 1 and US Highway 281) occurred in 1999 when the road elevation was raised to 1455 for 3.5 miles between BIA 1 and Ski Jump Road. A previous raise was completed in 1997, when a 0.74-mile portion of the road was raised to 1447.5.

General Protection Strategy: The analysis identified and evaluated one approach for protecting ND Highway 57 (between BIA Highway 1 and US Highway 281): raising the road.

Protection Strategy by Lake Level: The Economic Analysis of Devils Lake Alternatives analyzed the flood protection strategy of raising the road, with flood-protection decisions being made at various lake levels as Devils Lake continued to rise. Figure 2.15-2 shows the decision tree for ND Highway 57 (between BIA Highway 1 and US Highway 281). As shown on Figure 2.15-2, the stepwise approach to flood protection for ND Highway 57 (between BIA Highway 1 and US Highway 281) that was analyzed consisted of the following:

1. At lake elevation 1454, a decision would be made as to whether the road would be raised to 1460, or temporarily closed.

2. If the road were raised at the first action level, at lake elevation 1459 another decision would be made as to whether the road would be raised to 1468, or temporarily closed.

The maximum protection strategy that was analyzed at the first action level was raising the road to 1468. (Note that for the analysis, the decision regarding whether or not to raise the road is made at a time when the lake is one foot below the minimum highway elevation that resulted from the most recent raise.)

Interdependencies: The protection of ND Highway 57 (between BIA Highway 1 and US Highway 281) is related to the protection of several other features:

- Feature 2: City of Devils Lake – ND Highway 57 (between BIA Highway 1 and US Highway 281) is a major east-west route for traffic going south out of the city. Therefore, decisions on flood protection in the City of Devils Lake will impact traffic on ND Highway 57 (between BIA Highway 1 and US Highway 281).

- Feature 3: Fort Totten – ND Highway 57 (between BIA Highway 1 and US Highway 281) is the major road through Fort Totten. Therefore, decisions regarding flood protection in Fort Totten will impact traffic on ND Highway 57 (between BIA Highway 1 and US Highway 281).

- Feature 13: US Highway 2 – US Highway 2 would serve as an alternate east-west route if ND Highway 57 east of US Highway 281 was closed, and would take on the additional traffic that normally travels that highway.

- Feature 14: ND Highway 57 (between ND Highway 20 and BIA Highway 1) – These two features are extensions of the other, and therefore flood protection decisions on one section will impact the traffic on the other section.

- Feature 16: US Highway 281 (South of US Highway 2) – The terminus of ND Highway 57 (between BIA Highway 1 and US Highway 281) is US Highway 281 at the west end. Therefore, changes to traffic patterns on one ND Highway 57 will impact traffic on Feature 16.

- Feature 18: ND Highway 19 – These two roads are the major east-west routes around Devils Lake, and changes to traffic on one will affect the traffic counts on the other road.

- Feature 21: ND Highway 20 (City of Devils Lake Levee to ND Highway 57) – Traffic on ND Highway 57 (between BIA Highway 1 and US Highway 281) going into or out of the City of Devils Lake is routed on Feature 21 north of Highway 57. If Feature 15 is closed, traffic volumes on Feature 21 will be impacted.

- Feature 22: ND Highway 20 (ND Highway 57 to Tokio) – ND Highway 57 (between BIA Highway 1 and US Highway 281) and Feature 22 are the only two roads that span the "Narrows" across Devils Lake. Flood protection decisions on either road will impact the traffic volumes on the other road.

- Feature 24: BIA Highway 6 – Closure or relocation of Feature 24 will impact the amount of traffic on Feature 15 (and vise-versa) because the two features are alternate east-west travel routes through the Spirit Lake Nation Reservation.

Table 2.0-1, mentioned earlier in this report, provides a summary of the interdependencies among the features.

2.15.3 Feature Economics

Damages: For ND Highway 57 (between BIA Highway 1 and US Highway 281), the damages resulting from flooding were estimated up to the maximum lake level (1463). The damage computations for ND Highway 57 (between BIA Highway 1 and US Highway 281) are summarized in the accompanying Table 2.15-1.

The detour damages for ND Highway 57 (between BIA Highway 1 and US Highway 281), assume that all other features are open, and traffic is routed around the lake if ND Highway 57 (between BIA Highway 1 and US Highway 281) is temporarily closed. This was one of the four features in the Economics Analysis that was credited with the large detour damages around the lake (See discussion in Section 2.0.1.5). The computation of basin-wide damages required certain assumptions regarding interdependent roads in order to ensure that the basin-wide Economic Analysis was accurately representing overall traffic patterns.

The top portion of Table 2.15-1 gives a summary of the annual detour damages that would occur during the years when the highway is temporarily closed. It also shows road restoration damages that can be expected when the lake recedes after a period of flooding. Restoration damages include rebuilding the road with excavation, fill, surface material, and bridge repairs. Restoration damages are a per-event damage.

The lower portion of the table shows the breakdown of these summary values for each of the three action levels. It gives quantities in terms of miles per year (of extra miles traveled as a result of detours) and hours per year (of additional travel time resulting from detours) for the detour damages. Also shown are quantities and line-item damages for excavation, fabric liner, aggregate base course, and fill for road restoration work when waters recede.

Unit prices for all the damage computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for ND Highway 57 (between BIA Highway 1 and US Highway 281) are listed in the Feature 15 Assumptions listing, appended to this Section 2.15.

Costs: The costs of providing flood protection for ND Highway 57 (between BIA Highway 1 and US Highway 281) are detailed in the accompanying Table 2.15-2. Quantities and line-item totals are listed.

The top portion of the table gives the costs of providing flood protection (as represented in the analysis) by action level for various levels of flood protection. The lower portion of the table gives a breakdown of the quantities and costs by line item: fabric liner, aggregate base, fill, riprap, and bituminous pavement material.

Unit costs for all the cost computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for ND Highway 57 (between BIA Highway 1 and US Highway 281) are listed in the Feature 15 Assumptions listing, appended to this Section 2.15.

2.15.4 Results of Economic Analysis

The results of the Economic Analysis for the ND Highway 57 (between BIA Highway 1 and US Highway 281) are listed in Table 2.15-3.

Stochastic Analysis Results: The flood protection strategy that was analyzed for protecting ND Highway 57 (between BIA Highway 1 and US Highway 281) was two incremental road raises. This strategy is highlighted on the decision tree (Figure 2.15-2). The average annual net benefits for this strategy were greater than zero ($349,400). The BCR for this strategy was greater than one (3.01). These results indicate that this strategy was economically justified. The present worth annualized detour damages that would be prevented by this strategy were computed to be $503,100. The stochastic results are averages over 10,000 traces.

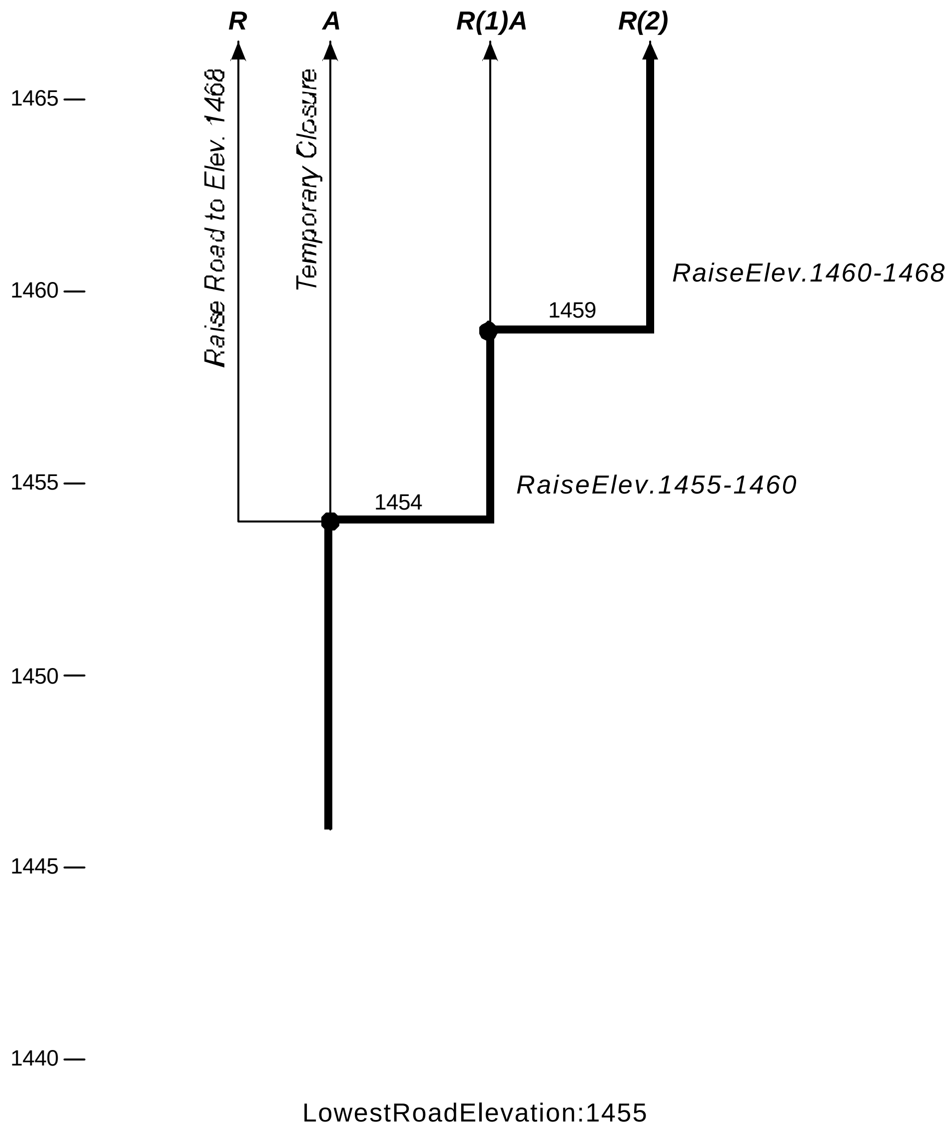
Results for Specific Scenarios: In the economic analysis, flood protection strategies were also analyzed for three specific climate futures. For ND Highway 57 (between BIA Highway 1 and US Highway 281), the identified strategy and the economic indices for each of the three climate futures are as follows:

- Wet Future – For the wet future, the annual net benefits were $4,173,700, and the BCR was 3.97, indicating that this strategy was economically justified. For this future, the present worth annualized detour damages that would be prevented were computed at $5,514,900.
- First Moderate Future – For the first moderate future, lake levels do not reach the first damage levels.
- Second Moderate Future – For the second moderate future, the annual net benefits were $853,900, and the BCR was 2.74, indicating that this strategy was economically justified. For this future, the present worth annualized detour damages that would be prevented were computed at $1,258,700.

Figure 2.15-1

LOCATION MAP
FEATURE 15: ND HIGHWAY 57
(BETWEEN BIA HIGHWAY 1
AND US HIGHWAY 281)
Devils Lake Infrastructure
Protection Study

DATA: 1997 USGS Digital Ortho Quad



P:3413612010DECISIONTREES\2012FIGURES\FIGURE2_15.CDR RLG 01-02-03

(thick line)	FloodProtectionStrategy
●	Decisionrequiredatthispoint
⊙	Triggerpointforaction,nodecisionneeded
R(1)	Incrementalroad raise(number oftimes)
R	Road raiseto1468
A	Temporary closureofroad

Figure2.15-2

DECISION TREE
FEATURE 15:NDHIGHWAY57
(BetweenBIAHighway1andU.S.Highway 281)
DevilsLakeInfrastructure ProtectionStudy

Table 2.15-1

Flood Damages
Feature 15: ND Highway 57 (between BIA Highway 1 and US Highway 281
Devils Lake Infrastructure Protection Study

DAMAGES

Action Levels	Annual Detour Damages (THOUSANDS)
AL1 - AL2	$9,488

DAMAGE BREAKDOWN

Damage	AL1 - AL2 Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Annual Detour Damages	ND Highway 57				
	HR/YEAR	385,700	HR	$7.00	$2,700
	MILES/YEAR	21,213,533	MILE	$0.32	$6,788
	Total				**$9,488**

Restoration Damages

Elevation	Total (THOUSANDS)	Excavation Quantity	Excavation Units	Excavation Unit Cost	Excavation Value (THOUSANDS)	Fabric Liner Quantity	Fabric Liner Units	Fabric Liner Unit Cost	Fabric Liner Value (THOUSANDS)	Aggregate Base Course Quantity	Aggregate Base Course Units	Aggregate Base Course Unit Cost	Aggregate Base Course Value (THOUSANDS)	Fill Quantity	Fill Units	Fill Unit Cost	Fill Value (THOUSANDS)	Bituminous Pavement Quantity	Bituminous Pavement Units	Bituminous Pavement Unit Cost	Bituminous Pavement Value (THOUSANDS)	Bridge Repair Quantity	Bridge Repair Units	Bridge Repair Unit Cost	Bridge Repair Cost (THOUSANDS)
1454	$0																								
1455	$3,644	101,600	CY	$2.65	$269	179,943	SY	$1.33	$239	21,872	CY	$21.20	$464	150,430	CY	$4.77	$718	40,979	TON	$47.70	$1,955	0	EA	$530,000	$0
1456	$3,644	101,600	CY	$2.65	$269	179,943	SY	$1.33	$239	21,872	CY	$21.20	$464	150,430	CY	$4.77	$718	40,979	TON	$47.70	$1,955	0	EA	$530,000	$0
1457	$4,599	128,200	CY	$2.65	$340	227,054	SY	$1.33	$302	27,599	CY	$21.20	$585	189,814	CY	$4.77	$905	51,707	TON	$47.70	$2,466	0	EA	$530,000	$0
1458	$4,599	128,200	CY	$2.65	$340	227,054	SY	$1.33	$302	27,599	CY	$21.20	$585	189,814	CY	$4.77	$905	51,707	TON	$47.70	$2,466	0	EA	$530,000	$0
1459	$4,599	128,200	CY	$2.65	$340	227,054	SY	$1.33	$302	27,599	CY	$21.20	$585	189,814	CY	$4.77	$905	51,707	TON	$47.70	$2,466	0	EA	$530,000	$0
1460	$4,599	128,200	CY	$2.65	$340	227,054	SY	$1.33	$302	27,599	CY	$21.20	$585	189,814	CY	$4.77	$905	51,707	TON	$47.70	$2,466	0	EA	$530,000	$0
1461	$5,460	152,200	CY	$2.65	$403	269,561	SY	$1.33	$359	32,765	CY	$21.20	$695	225,349	CY	$4.77	$1,075	61,387	TON	$47.70	$2,928	0	EA	$530,000	$0
1462	$5,460	152,200	CY	$2.65	$403	269,561	SY	$1.33	$359	32,765	CY	$21.20	$695	225,349	CY	$4.77	$1,075	61,387	TON	$47.70	$2,928	0	EA	$530,000	$0
1463	$5,460	152,200	CY	$2.65	$403	269,561	SY	$1.33	$359	32,765	CY	$21.20	$695	225,349	CY	$4.77	$1,075	61,387	TON	$47.70	$2,928	0	EA	$530,000	$0

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.

Table 2.15-2

Flood Protection Costs
Feature 15: ND Highway 57 (between BIA Highway 1 and US Highway 281)
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Action Level	Lake Elevation	R Maximum Raise at AL1	A Temporary Closure at AL1	R(1)A Raise at AL1; Temporary Closure at AL2	R(2) Raise at AL1, AL2
	(MSL)	(THOUSANDS)			
AL1	1454	$42,667	$0	$16,380	$16,380
AL2	1459	$0	$0	$0	$26,287

COST BREAKDOWN

		R									
		R(1)A									
		R(2)					R(2)				
		Lake Elevation 1454					Lake Elevation 1459				
Strategy		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Incremental Raise											
	Road Raise	ND Highway 57					ND Highway 57				
		Fabric Liner	340,101	SY	$1.33	$452	Fabric Liner	374,832	SY	$1.33	$499
		Aggregate Base	27,599	CY	$21.20	$585	Aggregate Base	5,167	CY	$21.20	$110
		Fill	672,052	CY	$9.00	$6,048	Fill	1,965,837	CY	$9.00	$17,693
		Riprap	227,589	CY	$30.00	$6,828	Riprap	250,831	CY	$30.00	$7,525
		Bituminous	51,707	TON	$47.70	$2,466	Bituminous	9,680	TON	$47.70	$462
		Bridge Rebuild	0	EA	$530,000	$0	Bridge Rebuild	0	EA	$530,000	$0
		Total				**$16,380**	**Total**				**$26,287**

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. The costs for the Maximum Raise at AL1 strategy (R) is equal to the sum of the costs for all incremental raises.

Table 2.15 - 3

Economic Analysis of Strategies for Highway 57 between BIA 1 and Highway 281 (Feature 15)

Stochastic Analysis (ST) — Mean Value over 10,000 Traces (Annual)

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Le	$0	$0	$0	$19,800	$503,100	$0	$523,000	$0	$0	--
R	Road Raise to 1468	$292,700	$0	$292,700	$0	$0	$0	$0	$523,000	$230,300	1.79
R(1)A	1 Road Raise: Then Temporary Closure During Flo	$112,300	$0	$112,300	$9,600	$117,900	$0	$127,500	$395,500	$283,100	3.52
R(2)	2 Incr. Road Raises	$173,500	$0	$173,500	$0	$0	$0	$0	$523,000	$349,400	3.01

Wet Future Scenario (WF) — (Annual)

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Le	$0	$0	$0	$65,200	########	$0	$5,580,100	$0	$0	--
R	Road Raise to 1468	########	$0	$1,738,100	$0	$0	$0	$0	$5,580,100	$3,842,000	3.21
R(1)A	1 Road Raise: Then Temporary Closure During Flo	$667,300	$0	$667,300	$72,900	########	$0	$2,403,800	$3,176,300	$2,509,000	4.76
R(2)	2 Incr. Road Raises	########	$0	$1,406,400	$0	$0	$0	$0	$5,580,100	$4,173,700	3.97

Moderate Future 1 Scenario (M1) — Mean Value over 10,000 Traces (Annual)

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Le	$0	$0	$0	$0	$0	$0	$0	$0	$0	--
R	Road Raise to 1468	$0	$0	$0	$0	$0	$0	$0	$0	$0	--
R(1)A	1 Road Raise: Then Temporary Closure During Flo	$0	$0	$0	$0	$0	$0	$0	$0	$0	--
R(2)	2 Incr. Road Raises	$0	$0	$0	$0	$0	$0	$0	$0	$0	--

Moderate Future 2 Scenario (M2) — (Annual)

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Le	$0	$0	$0	$85,100	########	$0	$1,343,800	$0	$0	--
R	Road Raise to 1468	########	$0	$1,276,100	$0	$0	$0	$0	$1,343,800	$67,700	1.05
R(1)A	1 Road Raise: Then Temporary Closure During Flo	$489,900	$0	$489,900	$0	$0	$0	$0	$1,343,800	$853,900	2.74
R(2)	2 Incr. Road Raises	$489,900	$0	$489,900	$0	$0	$0	$0	$1,343,800	$853,900	2.74

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.375% and rounded to the nearest $100.
* Total benefits are calculated as the total damages incurred for "temporary closure strategy" minus the total damages for the strategy implemented (G(S)).
The "No Protection" strategy for roads has been defined as temporary closure during floods at the first action level with restoration when the lake recedes.

Attachment to 2.15:
ND Highway 57 (between BIA Highway 1 and US Highway 281) Economic Analysis Assumptions

1. Plans for 2002 include raising Highway 57 from a minimum elevation of 1447.5 to 1455. For this analysis, the work was assumed completed and the new elevations were used.

A. General Assumptions

1. Decisions were assumed to occur when the lake level is within (or predicted by the National Weather Service to be within) 1 foot of the lowest road elevation. This assumption is consistent with current practices in the area as dictated by funding agencies. In the past, funding for road raises has not been available until the National Weather Service predicts on February 15th that the road will go under water during that year.

2. If the road includes a bridge having a low chord elevation below the lowest road elevation, it was assumed that no decision would occur until the lake level was within 1 foot of the lowest road elevation. This assumption follows current practices in the area.

B. Road Raises

1. Road raise costs were calculated in the manner presented in a previous study (*Devils Lake Flood Control: Economics Database Update: Transportation Report,* Barr Engineering Company, January 1998). Unit costs for construction materials were updated for inflation by multiplying them by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001. Additionally the cost of riprap and fill were increased from $20 to $30 and $4.50 to $9.00, respectively. Based on conversations with the NDDOT, railroad companies, and the Corps of Engineers the new costs for riprap and fill are more representative of the costs in the area.

2. The last road raise was assumed to be to elevation 1468. At this elevation, roads would be 5 feet above the assumed maximum lake level (elevation 1463).

3. The final incremental road raise (to elevation 1468) was assumed to be no more than 8 feet and no less than 4 feet.

C. Temporary Road Closure During Floods

1. It was assumed that if a road was temporarily closed, it would be restored after the lake level has receded 1 foot below the top of road. All of the road features in this study are highly traveled. It is very likely that people would want to use these roads again if the lake level receded after flooding, assuming that communities, businesses, farmsteads, and residents continue to generate the same level of traffic as at present.

2. Restoration damages were calculated in the manner presented in *Devils Lake Flood Control: Economics Database Update: Transportation Report*, Barr Engineering Company, January 1998. Unit costs for construction materials were updated for inflation by multiplying them by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001.

3. Detour damages were included for every year that a road is temporarily closed, as well as for the first year that the lake has receded. It was assumed that during the first year after the lake has receded, the road would be under restoration. During this first year, there would be both a detour damage and restoration damage. After this first year, there would be no further detour or restoration damages unless the lake rises to within 1 foot of the road again.

4. Restoration of a road would only occur after the lake has receded to 1 foot below the lowest elevation in that road. This was based on the assumption that restoration would only occur when there is no water on any part of the road and there would be only minor potential for wave action damage on the road.

5. Detour damages were calculated using a cost of $7 per hour of additional travel time, 1.5 people per vehicle, and $0.32 per mile for additional travel distance (Corps of Engineers, March, 2001). Additional time and miles traveled were taken from the results of the QRS II model used in *Devils Lake Flood Control: Economics Database Update: Transportation Report,* Barr Engineering Company, January 1998. The QRS II model determines the overall effect of a closed road on an entire network of traffic, incorporating the fact that traffic consists of trips having different origins and destinations.

6. The detour route for Highway 57 is around the lake to the west via Highway 281 and Highway 19. Woods-Rutten Road was considered as a detour route for Highway 57, but it was not retained as a viable alternative, because it would have to be significantly raised and improved to carry the traffic of Highway 57.

7. Detour paths were determined assuming that all other featured roads would be open. No effort was made to link detour routes with lake level.

8. Two features can have mutually interdependent detour routes if they are the most reasonable detours. In these cases, it was assumed that either the analyzed feature or the other feature would be raised or rerouted. In these cases, the interdependency was noted.

D. Road Reroutes

1. There was no logical reroute for this feature.

2.16 Summary of Economic Analysis Investigation for Feature 16: US Highway 281 (South of US Highway 2)

2.16.0 Flood Protection Strategy

The flood protection strategies that were analyzed in the Economic Analysis of Devils Lake Alternatives for US Highway 281 (South of US Highway 2) were relocation and incremental road raises.

2.16.1 General Information

Feature Type: Road

Location: Feature 16 is the 25.5-mile portion of US Highway 281 extending from just south of its intersection with ND Highway 57 at the south to its intersection with US Highway 2 outside of Churchs Ferry at the north. US Highway 281 (South of US Highway 2) passes through the City of Minnewaukan, and the Townships of Normania, Riggin, West Bay, Oberon, and Lallie in Benson County. The accompanying Figure 2.16-1 shows the feature's location and approximate extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: US Highway 281 (South of US Highway 2) is a two-lane bituminous National Highway. The entire highway route spans the United States from Canada to Texas. It is classified as a principal arterial highway and National Highway System route.

Significance: This portion of US Highway 281 is important because it is a major traffic route in the area, including the main route between Fort Totten and Minnewaukan. It is vital to serving local transportation, agricultural needs, and moving products through the area.

Damages: The flooding of Feature 16 would result in the following damages:

- Detour damages resulting from the added travel time and miles traveled when US Highway 281 (South of US Highway 2) is closed and traffic is detoured

- Restoration damages resulting from repairs that would be necessary to bring the highway back to a useable condition after a period of inundation

Owner/Sponsor: The North Dakota Department of Transportation is responsible for managing and maintaining US Highway 281 (South of US Highway 2).

Lead Federal Agency: The Federal Highway Administration would take the lead for US Highway 281 (South of US Highway 2) for any flood protection work that may take place.

2.16.2 Feature Protection

History of Flood Protection: Flood protection for US Highway 281 (South of US Highway 2) has thus far consisted of road raises. During 1997 and 1998, 8.8 miles of highway were raised to 1452.

General Protection Strategy: The analysis identified and evaluated two different approaches for protecting US Highway 281 (South of US Highway 2). These included:

- Highway relocation
- Incremental road raises

Protection Strategy by Lake Level: The Economic Analysis of Devils Lake Alternatives evaluated both of the flood protection strategies, with flood protection decisions being made at various lake levels as Devils Lake continued to rise. Figure 2.16-2 shows the decision tree for US Highway 281 (South of US Highway 2). As shown on Figure 2.16-2, the stepwise approach to flood protection for US Highway 281 (South of US Highway 2) that was analyzed consisted of the following:

1. At lake elevation 1447, a decision would be made as to whether the road would be raised to 1449, temporarily closed, or relocated to the west.
2. If the road were raised at the first action level, at lake elevation 1448 another decision would be made as to whether the road would be raised to 1454, temporarily closed, or relocated to the west.
3. If the road were raised at the second action level, at lake elevation 1453 another decision would be made as to whether the road would be raised to 1459, temporarily closed, or relocated to the west.
4. If the road were raised at the third action level, at lake elevation 1458 another decision would be made as to whether the road would be raised to 1464, temporarily closed, or relocated to the west.
5. If the road were raised at the fourth action level, at lake elevation 1463 another decision would be made as to whether the road would be raised to 1468, temporarily closed, or relocated to the west.

The maximum protection strategy that was analyzed at the first action level was relocating the road to the west. (Note that for the analysis, the decision regarding whether or not to raise the road is made at a time when the lake is one foot below the minimum highway elevation that resulted from the most recent raise.)

Interdependencies: The protection of US Highway 281(South of US Highway 2) is related to the protection of the following features:

- Feature 4: City of Minnewaukan – US Highway 281(South of US Highway 2) is the major transportation route through Feature 4. The protection strategy chosen for either, particularly if the strategy involves relocation, will have an impact on the other feature.
- Feature 13: US Highway 2 – The north end of Feature 16 is at its intersection with Feature 13. The protection strategy chosen for either, particularly if the strategy involves relocation, will have an impact on the other feature.
- Feature 14: ND Highway 57 (between ND Highway 20 and BIA Highway 1) – If Feature 16 is closed, Feature 14 would experience increased traffic as a detour route to Highway 2 and the City of Devils Lake.
- Feature 15: ND Highway 57 (between BIA Highway 1 and US Highway 281) – If Feature 16 is closed, Feature 14 would experience increased traffic as a detour route to Highway 2 and the City of Devils Lake.
- Feature 17: US Highway 281 (North of US Highway 2) – Features 17 and 16 are segments of the same highway, so the protection strategy chosen for either, particularly if the strategy involves relocation, will have an impact on the other feature.
- Feature 18: ND Highway 19 – ND Highway 19 has its west terminus at US Highway 281 (South of US Highway 2). Therefore, if Feature 16 were closed, traffic on ND Highway 19 would be reduced.
- Feature 21: ND Highway 20 (City of Devils Lake Levee to ND Highway 57) – If Feature 16 is closed, Feature 21 would experience increased traffic as a detour route to Highway 2 and the City of Devils Lake.
- Feature 23: BIA Highway 1 – If Feature 16 is closed, Feature 23 would experience increased traffic as a detour route.
- Feature 24: BIA Highway 6 – If Feature 16 is closed, Feature 24 would experience increased traffic as a detour route.

Table 2.0-1, mentioned earlier in this report, provides a summary of the interdependencies among the features.

2.16.3 Feature Economics

Damages: For US Highway 281 (South of US Highway 2), the damages resulting from flooding were estimated up to the maximum lake level (1463). The damage computations for Feature 16 are summarized in the accompanying Table 2.16-1.

The first portion of the table shows a summary of the detour damages that would occur during years that the highway was flooded. The second portion of the table is a breakdown of the damages associated with each level including annual detour damages and restoration damage costs. Restoration damages represent the costs to restore Feature 16 once the lake levels recede after a period of flooding. Restoration damages include rebuilding the road with excavation, fill, surface material, and bridge repairs. Restoration damages are a per-event damage.

Unit costs for all the damage computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for US Highway 281 (South of US Highway 2) are listed in the Feature 16 Assumptions listing, appended to this Section 2.16.

Costs: The costs of providing flood protection for US Highway 281 (South of US Highway 2) are detailed in the accompanying Table 2.16-2. Unit costs, data sources, and relevant assumptions are listed.

The first portion of the table shows the cost associated with each action level (1447, 1448, 1453, 1458, and 1463). The second portion of the table is a breakdown of incremental road raises and relocation costs. Incremental road raise costs are broken down into six categories: fabric liner, aggregate base, fill, riprap, bituminous, and bridge work. Relocation assumes a per mile cost.

Unit costs for all the cost computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for US Highway 281 (South of US Highway 2) are listed in the Feature 16 Assumptions listing, appended to this Section 2.16.

2.16.4 Results of Economic Analysis

The results of the Economic Analysis for the US Highway 281 (South of US Highway 2) are listed in Table 2.16-3.

Stochastic Analysis Results: The stochastic analysis indicated that the largest net benefits for protecting US Highway 281 (South of US Highway 2) was incremental road raises. This strategy is highlighted on the decision tree (Figure 2.16-2). The average annual net benefits for this strategy were greater than zero ($199,600). The BCR for this strategy was greater than one (1.08). These results indicate that this strategy was economically justified. The present worth annualized detour damages that would be prevented by this strategy were computed to be $2,386,000. The stochastic results are averages over 10,000 traces.

Results for Specific Scenarios: In the economic analysis, flood protection strategies were also analyzed for three specific climate futures. For US Highway 281 (South of US Highway 2), the identified strategy and the economic indices for each of the three climate futures are as follows:

- Wet Future – For the wet future, the annual net benefits were -$801,600, and the BCR was 0.87, indicating that the incremental raise strategy was not economically justified. For this future, the present worth annualized detour damages that would be prevented were computed at $5,214,000. The relocation strategy had annual net benefits that were $2,149,800, and the BCR was 2.44, indicating that the relocation strategy would be economically justified under the wet future. The present worth annualized detour damages that would be prevented would be reduced to $3,639,000 (detour damages are reduced by the annual reroute costs).
- First Moderate Future – For the first moderate future, the annual net benefits were $1,275,700, and the BCR was 1.99, indicating that the incremental raise strategy was economically justified. For this future, the present worth annualized detour damages that would be prevented were computed at $2,119,500.
- Second Moderate Future – For the second moderate future, the annual net benefits were $915,700, and the BCR was 1.24, indicating that the incremental raise strategy was economically justified. For this future, the present worth annualized detour damages that would be prevented were computed at $4,494,500.

Figure 2.16-1
LOCATION MAP
FEATURE 16: US HIGHWAY 281
(SOUTH OF US HIGHWAY 2)
Devils Lake Infrastructure
Protection Study

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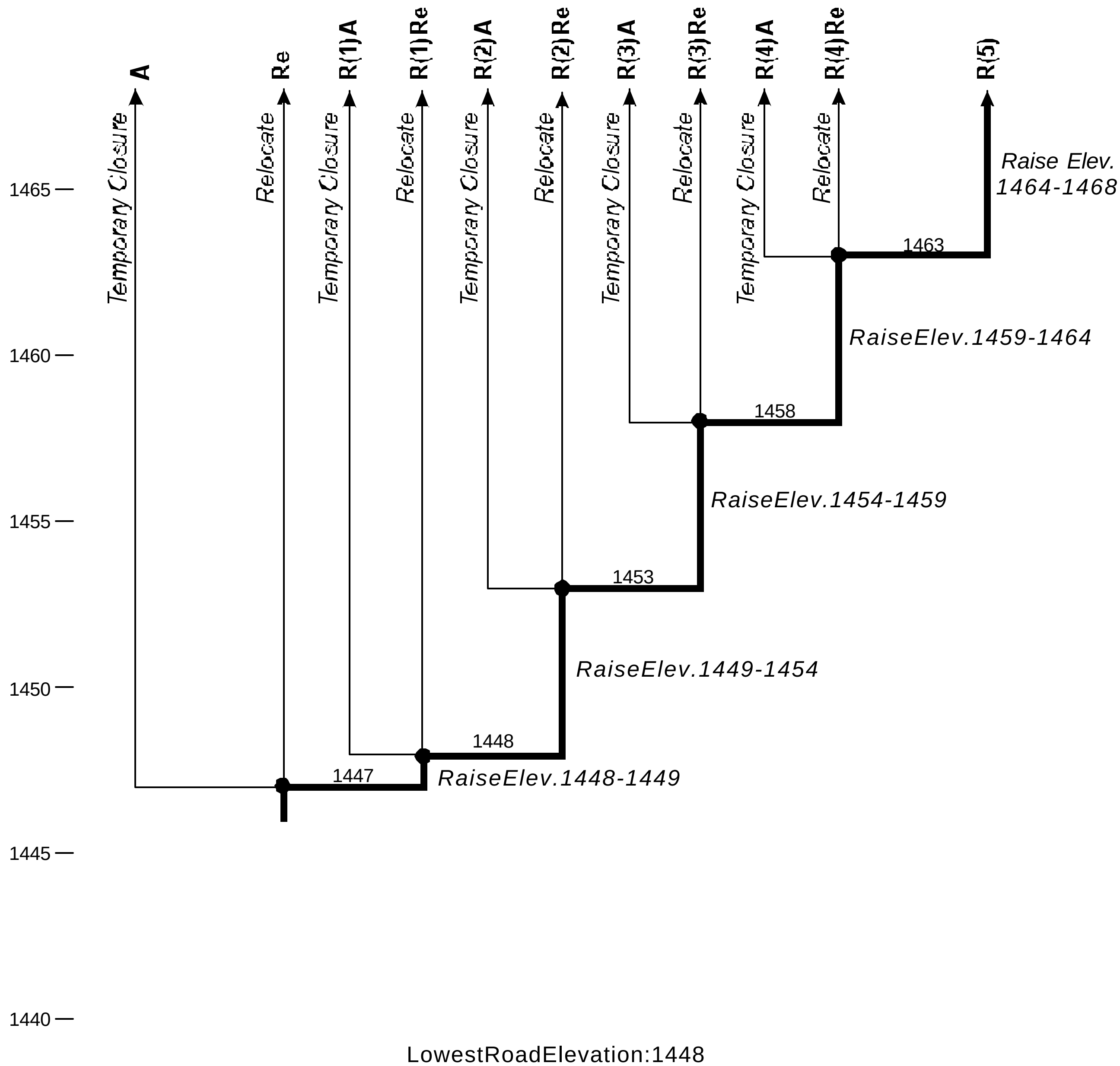
DATA: 1997 USGS Digital Ortho Quad



(thick line)	FloodProtectionStrategy
●	Decisionrequiredatthispoint
⊙	Triggerpointforaction,nodecisionneeded
R(1)	Incrementalroad raise(number oftimes)
A	Temporary closureofroad
Re	Relocate

Figure2.16-2

DECISION TREE
FEATURE 16:U.S.HIGHWAY281
(South of U.S.Highway 2)
DevilsLakeInfrastructure ProtectionStudy

Table 2.16-1

Flood Damages
Feature 16: US Highway 281 (South of US Highway 2)
Devils Lake Infrastructure Protection Study

DAMAGES

Action Levels	Strategy	Annual Detour Damages
		(THOUSANDS)
AL1 - AL5	A - Temporary Closure at AL1	$5,214
	Re - Relocate at AL1	$1,575

DAMAGE BREAKDOWN

	AL1 - AL5				
Damage	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Annual Detour Damages	US HWY 281				
	HR/YEAR	211,934	HR	$7.00	$1,484
	MILES/YEAR	11,656,390	MILE	$0.32	$3,730
	Total				**$5,214**
Annual Relocation Detour Damages	US HWY 281				
	HR/YEAR	64,025	HR	$7.00	$448
	MILES/YEAR	3,521,410	MILE	$0.32	$1,127
	Total				**$1,575**

Restoration Damages

		Excavation				Fabric Liner				Aggregate Base Course			
Elevation	Total (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)
1447	$0												
1448	$2,567	42,000	CY	$2.65	$111	74,386	SY	$1.33	$99	9,042	CY	$21.20	$192
1449	$2,567	42,000	CY	$2.65	$111	74,386	SY	$1.33	$99	9,042	CY	$21.20	$192
1450	$2,567	42,000	CY	$2.65	$111	74,386	SY	$1.33	$99	9,042	CY	$21.20	$192
1451	$7,875	190,000	CY	$2.65	$504	336,508	SY	$1.33	$448	40,903	CY	$21.20	$867
1452	$11,678	296,000	CY	$2.65	$784	524,244	SY	$1.33	$697	63,722	CY	$21.20	$1,351
1453	$12,453	317,600	CY	$2.65	$842	562,500	SY	$1.33	$748	68,372	CY	$21.20	$1,449
1454	$14,634	378,400	CY	$2.65	$1,003	670,182	SY	$1.33	$891	81,461	CY	$21.20	$1,727
1455	$14,634	378,400	CY	$2.65	$1,003	670,182	SY	$1.33	$891	81,461	CY	$21.20	$1,727
1456	$16,155	420,800	CY	$2.65	$1,115	745,277	SY	$1.33	$991	90,589	CY	$21.20	$1,920
1457	$16,155	420,800	CY	$2.65	$1,115	745,277	SY	$1.33	$991	90,589	CY	$21.20	$1,920
1458	$16,693	435,800	CY	$2.65	$1,155	771,843	SY	$1.33	$1,027	93,818	CY	$21.20	$1,989
1459	$17,180	449,400	CY	$2.65	$1,191	795,930	SY	$1.33	$1,059	96,746	CY	$21.20	$2,051
1460	$17,180	449,400	CY	$2.65	$1,191	795,930	SY	$1.33	$1,059	96,746	CY	$21.20	$2,051
1461	$17,762	465,600	CY	$2.65	$1,234	824,622	SY	$1.33	$1,097	100,233	CY	$21.20	$2,125
1462	$17,762	465,600	CY	$2.65	$1,234	824,622	SY	$1.33	$1,097	100,233	CY	$21.20	$2,125
1463	$17,762	465,600	CY	$2.65	$1,234	824,622	SY	$1.33	$1,097	100,233	CY	$21.20	$2,125

	Fill				Bituminous Pavement				Bridge Repair			
Elevation	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Cost (THOUSANDS)
1447												
1448	62,186	CY	$4.77	$297	16,940	TON	$47.70	$808	2	EA	$530,000	$1,060
1449	62,186	CY	$4.77	$297	16,940	TON	$47.70	$808	2	EA	$530,000	$1,060
1450	62,186	CY	$4.77	$297	16,940	TON	$47.70	$808	2	EA	$530,000	$1,060
1451	281,316	CY	$4.77	$1,342	76,633	TON	$47.70	$3,655	2	EA	$530,000	$1,060
1452	438,260	CY	$4.77	$2,091	119,387	TON	$47.70	$5,695	2	EA	$530,000	$1,060
1453	470,241	CY	$4.77	$2,243	128,099	TON	$47.70	$6,110	2	EA	$530,000	$1,060
1454	560,262	CY	$4.77	$2,672	152,621	TON	$47.70	$7,280	2	EA	$530,000	$1,060
1455	560,262	CY	$4.77	$2,672	152,621	TON	$47.70	$7,280	2	EA	$530,000	$1,060
1456	623,040	CY	$4.77	$2,972	169,723	TON	$47.70	$8,096	2	EA	$530,000	$1,060
1457	623,040	CY	$4.77	$2,972	169,723	TON	$47.70	$8,096	2	EA	$530,000	$1,060
1458	645,249	CY	$4.77	$3,078	175,773	TON	$47.70	$8,384	2	EA	$530,000	$1,060
1459	665,385	CY	$4.77	$3,174	181,258	TON	$47.70	$8,646	2	EA	$530,000	$1,060
1460	665,385	CY	$4.77	$3,174	181,258	TON	$47.70	$8,646	2	EA	$530,000	$1,060
1461	689,371	CY	$4.77	$3,288	187,792	TON	$47.70	$8,958	2	EA	$530,000	$1,060
1462	689,371	CY	$4.77	$3,288	187,792	TON	$47.70	$8,958	2	EA	$530,000	$1,060
1463	689,371	CY	$4.77	$3,288	187,792	TON	$47.70	$8,958	2	EA	$530,000	$1,060

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.

Table 2.16-2

Flood Protection Costs
Feature 16: US Highway 281 (South of US Highway 2)
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Action Level	Lake Elevation	A Temporary Closure at AL1	Re Relocate at AL1	R(1)A Raise at AL1; Temporary Closure at AL2	R(1)Re Raise at AL1; Relocate at AL2	R(2)A Raise at AL1,AL2; Temporary Closure at AL3	R(2)Re Raise at AL1,AL2; Relocate at AL3	R(3)A Raise at AL1, AL2, AL3; Temporary Closure at AL4	R(3)Re Raise at AL1, AL2, AL3; Relocate at AL4	R(4)A Raise at AL1, AL2, AL3, AL4; Temporary Closure at AL5	R(4)Re Raise at AL1, AL2, AL3, AL4; Relocate at AL5	R(5) Raise at AL1, AL2, AL3, AL4, AL5
	(MSL)	(THOUSANDS)										
AL1	1447	$0	$23,718	$3,829	$3,829	$3,829	$3,829	$3,829	$3,829	$3,829	$3,829	$3,829
AL2	1448	$0	$0	$0	$23,718	$37,471	$37,471	$37,471	$37,471	$37,471	$37,471	$37,471
AL3	1453	$0	$0	$0	$0	$0	$23,718	$43,464	$43,464	$43,464	$43,464	$43,464
AL4	1458	$0	$0	$0	$0	$0	$0	$0	$23,718	$52,807	$52,807	$52,807
AL5	1463	$0	$0	$0	$0	$0	$0	$0	$0	$0	$23,718	$48,947

COST BREAKDOWN

Re

Lake Elevation 1447 — R(1)A, R(1)Re, R(2)A, R(2)Re, R(3)A, R(3)Re, R(4)A, R(4)Re, R(5)

Strategy / Incremental Raise		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
	Road Raise	US Highway 281				
		Fabric Liner	66,468	SY	$1.33	$88
		Aggregate Base	9,041	CY	$21.20	$192
		Fill	38,500	CY	$9.00	$347
		Riprap	44,479	CY	$30.00	$1,334
		Bituminous	16,940	TON	$47.70	$808
		Bridge Rebuild	2	EA	$530,000	$1,060
		Total				**$3,829**

Lake Elevation 1448 — R(2)A, R(2)Re, R(3)A, R(3)Re, R(4)A, R(4)Re, R(5)

Strategy / Incremental Raise		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
	Road Raise	US Highway 281				
		Fabric Liner	782,877	SY	$1.33	$1,041
		Aggregate Base	72,419	CY	$21.20	$1,535
		Fill	1,294,000	CY	$9.00	$11,646
		Riprap	523,887	CY	$30.00	$15,717
		Bituminous	135,681	TON	$47.70	$6,472
		Bridge Rebuild	2	EA	$530,000	$1,060
		Total				**$37,471**

Lake Elevation 1453 — R(3)A, R(3)Re, R(4)A, R(4)Re, R(5)

Strategy / Incremental Raise		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
	Road Raise	US Highway 281				
		Fabric Liner	686,444	SY	$1.33	$913
		Aggregate Base	15,285	CY	$21.20	$324
		Fill	2,891,193	CY	$9.00	$26,021
		Riprap	459,356	CY	$30.00	$13,781
		Bituminous	28,637	TON	$47.70	$1,366
		Bridge Rebuild	2	EA	$530,000	$1,060
		Total				**$43,464**

Lake Elevation 1458 — R(4)A, R(4)Re, R(5)

Strategy / Incremental Raise		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
	Road Raise	US Highway 281				
		Fabric Liner	673,488	SY	$1.33	$896
		Aggregate Base	3,488	CY	$21.20	$74
		Fill	4,105,002	CY	$9.00	$36,945
		Riprap	450,686	CY	$30.00	$13,521
		Bituminous	6,534	TON	$47.70	$312
		Bridge Rebuild	2	EA	$530,000	$1,060
		Total				**$52,807**

Lake Elevation 1463 — R(5)

Strategy / Incremental Raise		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
	Road Raise	US Highway 281				
		Fabric Liner	525,595	SY	$1.33	$699
		Aggregate Base	0	CY	$21.20	$0
		Fill	4,070,793	CY	$9.00	$36,636
		Riprap	351,719	CY	$30.00	$10,552
		Bituminous	0	TON	$47.70	$0
		Bridge Rebuild	2	EA	$530,000	$1,060
		Total				**$48,947**

Relocation (Re at 1447; R(1)Re at 1448; R(2)Re at 1453; R(3)Re at 1458; R(4)Re at 1463)

Strategy		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Relocation		Reroute Path: BC 28, BC 25, US 2				
	Reroute	Upgrade BC 28, BC 25				
			34.5	MILE	$694,300	$23,718
		Total				**$23,718**

The same relocation breakdown (Reroute Path: BC 28, BC 25, US 2; Upgrade BC 28, BC 25; 34.5 MILE at $694,300 = $23,718; Total $23,718) is printed under each lake elevation: R(1)Re, R(2)Re, R(3)Re, R(4)Re.

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.

Table 2.16 - 3

Economic Analysis of Strategies for Highway 281 South of US Highway 2
(Feature 16)

Strategy		Stochastic Analysis (ST) Mean Value over 10,000 Traces (Annual)									
		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Level	$0	$0	$0	$226,900	$2,386,000	$0	$2,612,800	$0	$0	--
Re	Relocation of Road at First Action Level	$0	$1,484,000	$1,484,000	$0	$0	$1,569,300	$1,569,300	$1,043,400	-$440,500	0.70
R(1)A	1 Road Raise: Then Temporary Closure During Floods	$239,600	$0	$239,600	$186,400	$1,610,500	$0	$1,797,000	$815,800	$576,300	3.40
R(2)A	2 Road Raises: Then Temporary Closure During Floods	$1,879,500	$0	$1,879,500	$90,500	$350,200	$0	$440,700	$2,172,100	$292,500	1.16
R(3)A	3 Road Raises: Then Temporary Closure During Floods	$2,245,200	$0	$2,245,200	$39,300	$93,900	$0	$133,300	$2,479,500	$234,200	1.10
R(4)A	4 Road Raises: Then Temporary Closure During Floods	$2,401,300	$0	$2,401,300	$300	$2,700	$0	$3,000	$2,609,800	$208,500	1.09
R(1)Re	1 Road Raise: Then Relocate	$239,600	$1,038,000	$1,277,600	$0	$0	$1,087,900	$1,087,900	$1,524,900	$247,300	1.19
R(2)Re	2 Road Raises: Then Relocate	$1,879,500	$199,600	$2,079,100	$0	$0	$199,200	$199,200	$2,413,700	$334,500	1.16
R(3)Re	3 Road Raises: Then Relocate	$2,245,200	$70,100	$2,315,400	$0	$0	$68,900	$68,900	$2,543,900	$228,500	1.10
R(4)Re	4 Road Raises: Then Relocate	$2,401,300	$5,700	$2,407,100	$0	$0	$5,600	$5,600	$2,607,200	$200,100	1.08
R(5)	5 Road Raises	$2,413,200	$0	$2,413,200	$0	$0	$0	$0	$2,612,800	$199,600	1.08

Strategy		Wet Future Scenario (WF) (Annual)									
		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Level	$0	$0	$0	$0	$5,214,000	$0	$5,214,000	$0	$0	--
Re	Relocation of Road at First Action Level	$0	$1,489,200	$1,489,200	$0	$0	$1,575,000	$1,575,000	$3,639,000	$2,149,800	2.44
R(1)A	1 Road Raise: Then Temporary Closure During Floods	$240,400	$0	$240,400	$0	$4,886,600	$0	$4,886,600	$327,400	$87,000	1.36
R(2)A	2 Road Raises: Then Temporary Closure During Floods	$2,452,100	$0	$2,452,100	$225,300	$3,329,600	$0	$3,554,900	$1,659,100	-$793,000	0.68
R(3)A	3 Road Raises: Then Temporary Closure During Floods	$4,335,500	$0	$4,335,500	$234,800	$1,672,600	$0	$1,907,400	$3,306,700	-$1,028,900	0.76
R(4)A	4 Road Raises: Then Temporary Closure During Floods	$6,015,600	$0	$6,015,600	$0	$0	$0	$0	$5,214,000	-$801,600	0.87
R(1)Re	1 Road Raise: Then Relocate	$240,400	$1,399,900	$1,640,300	$0	$0	$1,476,100	$1,476,100	$3,737,900	$2,097,600	2.28
R(2)Re	2 Road Raises: Then Relocate	$2,452,100	$1,027,800	$3,479,900	$0	$0	$1,063,700	$1,063,700	$4,150,200	$670,400	1.19
R(3)Re	3 Road Raises: Then Relocate	$4,335,500	$754,600	$5,090,100	$0	$0	$761,100	$761,100	$4,453,000	-$637,200	0.87
R(4)Re	4 Road Raises: Then Relocate	$6,015,600	$0	$6,015,600	$0	$0	$0	$0	$5,214,000	-$801,600	0.87
R(5)	5 Road Raises	$6,015,600	$0	$6,015,600	$0	$0	$0	$0	$5,214,000	-$801,600	0.87

Strategy		Moderate Future 1 Scenario (M1) (Annual)									
		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Level	$0	$0	$0	$450,200	$2,119,500	$0	$2,569,700	$0	$0	--
Re	Relocation of Road at First Action Level	$0	$1,489,200	$1,489,200	$0	$0	$1,575,000	$1,575,000	$994,700	-$494,400	0.67
R(1)A	1 Road Raise: Then Temporary Closure During Floods	$240,400	$0	$240,400	$76,900	$414,000	$0	$490,900	$2,078,700	$1,838,400	8.65
R(2)A	2 Road Raises: Then Temporary Closure During Floods	$1,294,000	$0	$1,294,000	$0	$0	$0	$0	$2,569,700	$1,275,700	1.99
R(3)A	3 Road Raises: Then Temporary Closure During Floods	$1,294,000	$0	$1,294,000	$0	$0	$0	$0	$2,569,700	$1,275,700	1.99
R(4)A	4 Road Raises: Then Temporary Closure During Floods	$1,294,000	$0	$1,294,000	$0	$0	$0	$0	$2,569,700	$1,275,700	1.99
R(1)Re	1 Road Raise: Then Relocate	$240,400	$666,800	$907,300	$0	$0	$663,800	$663,800	$1,905,900	$998,600	2.10
R(2)Re	2 Road Raises: Then Relocate	$1,294,000	$0	$1,294,000	$0	$0	$0	$0	$2,569,700	$1,275,700	1.99
R(3)Re	3 Road Raises: Then Relocate	$1,294,000	$0	$1,294,000	$0	$0	$0	$0	$2,569,700	$1,275,700	1.99
R(4)Re	4 Road Raises: Then Relocate	$1,294,000	$0	$1,294,000	$0	$0	$0	$0	$2,569,700	$1,275,700	1.99
R(5)	5 Road Raises	$1,294,000	$0	$1,294,000	$0	$0	$0	$0	$2,569,700	$1,275,700	1.99

Strategy		Moderate Future 2 Scenario (M2) (Annual)									
		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Level	$0	$0	$0	$173,200	$4,494,500	$0	$4,667,700	$0	$0	--
Re	Relocation of Road at First Action Level	$0	$1,489,200	$1,489,200	$0	$0	$1,575,000	$1,575,000	$3,092,700	$1,603,500	2.08
R(1)A	1 Road Raise: Then Temporary Closure During Floods	$240,400	$0	$240,400	$350,900	$3,442,300	$0	$3,793,300	$874,500	$634,100	3.64
R(2)A	2 Road Raises: Then Temporary Closure During Floods	$2,452,100	$0	$2,452,100	$321,300	$806,100	$0	$1,127,500	$3,540,200	$1,088,100	1.44
R(3)A	3 Road Raises: Then Temporary Closure During Floods	$3,752,000	$0	$3,752,000	$0	$0	$0	$0	$4,667,700	$915,700	1.24
R(4)A	4 Road Raises: Then Temporary Closure During Floods	$3,752,000	$0	$3,752,000	$0	$0	$0	$0	$4,667,700	$915,700	1.24
R(1)Re	1 Road Raise: Then Relocate	$240,400	$1,399,900	$1,640,300	$0	$0	$1,476,100	$1,476,100	$3,191,600	$1,551,300	1.95
R(2)Re	2 Road Raises: Then Relocate	$2,452,100	$709,400	$3,161,500	$0	$0	$710,900	$710,900	$3,956,800	$795,300	1.25
R(3)Re	3 Road Raises: Then Relocate	$3,752,000	$0	$3,752,000	$0	$0	$0	$0	$4,667,700	$915,700	1.24
R(4)Re	4 Road Raises: Then Relocate	$3,752,000	$0	$3,752,000	$0	$0	$0	$0	$4,667,700	$915,700	1.24
R(5)	5 Road Raises	$3,752,000	$0	$3,752,000	$0	$0	$0	$0	$4,667,700	$915,700	1.24

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.375% and rounded to the nearest $100.
* Total benefits are calculated as the total damages incurred for "temporary closure strategy" minus the total damages for the strategy implemented (G(S)).
The "No Protection" strategy for roads has been defined as temporary closure during floods at the first action level with restoration when the lake recedes.
The top action level (1463) is never reached in the 10,000 traces, rendering some of the costs and damages equal between different strategies.

Attachment to 2.16:
US Highway 281 (South of US Highway 2) Economic Analysis Assumptions

No feature-specific assumptions were made for Feature 16.

A. General Assumptions

1. Decisions were assumed to occur when the lake level is within (or predicted by the National Weather Service to be within) 1 foot of the lowest road elevation. This assumption is consistent with current practices in the area as dictated by funding agencies. In the past, funding for road raises has not been available until the National Weather Service predicts on February 15th that the road will go under water during that year.

2. If the road includes a bridge having a low chord elevation below the lowest road elevation, it was assumed that no decision would occur until the lake level was within 1 foot of the lowest road elevation. This assumption follows current practices in the area.

B. Road Raises

1. Road raise costs were calculated in the manner presented in a previous study (*Devils Lake Flood Control: Economics Database Update: Transportation Report*, Barr Engineering Company, January 1998). Unit costs for construction materials were updated for inflation by multiplying them by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001. Additionally the cost of riprap and fill were increased from $20 to $30 and $4.50 to $9.00, respectively. Based on conversations with the NDDOT, railroad companies, and the Corps of Engineers the new costs for riprap and fill are more representative of the costs in the area.

2. The last road raise was assumed to be to elevation 1468. At this elevation, roads would be 5 feet above the assumed maximum lake level (elevation 1463).

3. The final incremental road raise (to elevation 1468) was assumed to be no more than 8 feet and no less than 4 feet.

C. Temporary Road Closure During Floods

1. It was assumed that if a road was temporarily closed, it would be restored after the lake level has receded 1 foot below the top of road. All of the road features in this study are highly traveled. It is very likely that people would want to use these roads again if the lake level receded after flooding, assuming that communities, businesses, farmsteads, and residents continue to generate the same level of traffic as at present.

2. Restoration damages were calculated in the manner presented in *Devils Lake Flood Control: Economics Database Update: Transportation Report*, Barr Engineering Company, January 1998. Unit costs for construction materials were updated for inflation by multiplying them by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001.

3. Detour damages were included for every year that a road is temporarily closed, as well as for the first year that the lake has receded. It was assumed that during the first year after the lake has receded, the road would be under restoration. During this first year, there would be both a detour damage and restoration damage. After this first year, there would be no further detour or restoration damages unless the lake rises to within 1 foot of the road again.

4. Restoration of a road would only occur after the lake has receded to 1 foot below the lowest elevation in that road. This was based on the assumption that restoration would only occur when there is no water on any part of the road and there would be only minor potential for wave action damage on the road.

5. Detour damages were calculated using a cost of $7 per hour of additional travel time, 1.5 people per vehicle, and $0.32 per mile for additional travel distance (Corps of Engineers, March, 2001). Additional time and miles traveled were taken from the results of the QRS II model used in *Devils Lake Flood Control: Economics Database Update: Transportation Report,* Barr Engineering Company, January 1998. The QRS II model determines the overall effect of a closed road on an entire network of traffic, incorporating the fact that traffic consists of trips having different origins and destinations.

6. Detour paths were determined assuming that all other featured roads would be open. No effort was made to link detour routes with lake level.

7. Two features can have mutually interdependent detour routes if they are the most reasonable detours. In these cases, it was assumed that either the analyzed feature or the other feature would be raised or rerouted. In these cases, the interdependency was noted.

D. Road Reroutes

1. It was assumed that if a road was permanently rerouted, the old route for that road would never be restored. Rerouting a road is an expensive option, so it was assumed that once this investment was made, the old road would not be considered usable. However, detour damages (reflecting the longer distance on the new alignment) will continue to be incurred for every year that the rerouted road is in use. This detour damage is estimated with same model output from the QRS II model described in the assumptions regarding temporary closure during flooding.

2. It was assumed that the rerouted path for any feature would be upgraded to the same level (road width and speed limit) as the existing feature.

3. Road reroutes do not necessarily have to be onto roads that are currently at or above the maximum elevation 1468. If there is a logical reroute path that would require a minor road lift (<10 feet), this reroute path could still be acceptable.

4. The only features that have reroute strategies are Highway 281 north of US Highway 2, and Highway 281 south of US Highway 2. All other strategies either have no logical reroute or have routes that would require more than 10-foot raises.

2.17 Summary of Economic Analysis Investigation for Feature 17: US Highway 281 (North of US Highway 2)

2.17.0 Flood Protection Strategy

The flood protection strategies that were analyzed in the Economic Analysis of Devils Lake Alternatives for US Highway 281 (North of US Highway 2) were relocation and incremental road raises.

2.17.1 General Information

Feature Type: Road

Location: Feature 17 is the portion of US Highway 281 that is north of US Highway 2, located in Towner County and along the borders of Ramsey and Benson Counties. It extends 16.5 miles from its intersection with US Highway 2 near Churchs Ferry at the south to Cando at the north. Feature 17 passes through the Townships of Olson, Cando, Atkins, Maza, Irvine, Chain Lakes, Normania, and Coulee. The accompanying Figure 2.17-1 shows the feature's location and approximate extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: US Highway 281 (North of US Highway 2) is a two-lane bituminous National Highway. The entire highway route spans the United States from Canada to Texas. It is classified as a principal arterial highway and National Highway System route.

Significance: This portion of US Highway 281 is important because it is a major traffic route in the area, including the main route between Cando and Churchs Ferry. It is vital to serving local transportation, agricultural needs, and moving products through the area.

Damages: The flooding of Feature 17 would result in the following damages:

- Detour damages resulting from the added travel time and miles traveled when US Highway 281 (North of US Highway 2) is closed and traffic is detoured.
- Restoration damages resulting from repairs that would be necessary to bring the highway back to a useable condition after a period of inundation.

Owner/Sponsor: The North Dakota Department of Transportation is responsible for managing and maintaining US Highway 281 (North of US Highway 2).

Lead Federal Agency: The Federal Highway Administration would take the lead for US Highway 281 (North of US Highway 2) for any flood protection work that may take place.

2.17.2 Feature Protection

History of Flood Protection: Flood protection for US Highway 281 (North of US Highway 2) has not been an issue to date. Currently all of this section of road has been above the level of the rising water.

General Protection Strategy: The analysis identified and evaluated several different approaches for protecting US Highway 281 (North of US Highway 2). These included:

- Highway relocation
- Incremental road raises

Protection Strategy by Lake Level: The Economic Analysis of Devils Lake Alternatives evaluated both of the protection strategies, with flood protection decisions being made at various lake levels as Devils Lake continued to rise. Figure 2.17-2 shows the decision tree for US Highway 281 (North of US Highway 2). As shown on Figure 2.17-2, the stepwise approach to flood protection for US Highway 281 (North of US Highway 2) that was analyzed consisted of the following:

1. At lake elevation 1451, a decision would be made as to whether the road would be raised to 1457, temporarily closed, or relocated to the west.
2. If the road were raised at the first action level, at lake elevation 1456 another decision would be made as to whether the road would be raised to 1462, temporarily closed, or relocated to the west.
3. If the road were raised at the second action level, at lake elevation 1461 another decision would be made as to whether the road would be raised to 1468, temporarily closed, or relocated to the west.

The maximum protection strategy that was analyzed at the first action level was relocating the road to the west. (Note that for the analysis, the decision regarding whether or not to raise the road is made at a time when the lake is one foot below the minimum highway elevation that resulted from the most recent raise.)

Interdependencies: The protection of US Highway 281 (North of US Highway 2) is related to the protection of the following features:

- Feature 1: Churchs Ferry – Churchs Ferry is located at the south end of Feature 17. The protection strategy chosen for either, particularly if the strategy involves relocation, will have an impact on the other feature.

- Feature 20: ND Highway 20 (North of the City of Devils Lake) – If US Highway 281 (North of US Highway 2) is temporarily closed, Feature 20 would experience increased traffic as a detour route.

Table 2.0-1, mentioned earlier in this report, provides a summary of the interdependencies among the features.

2.17.3 Feature Economics

Damages: For US Highway 281 (North of US Highway 2), the damages resulting from flooding were estimated up to the maximum lake level (1463). The damage computations for Feature 17 are summarized in the accompanying Table 2.17-1.

The first portion of the table summarizes the detour damages that would occur if the highway were temporarily closed. The second portion of the table is a breakdown of the damages associated with each action level, including annual detour damages and restoration damage costs. Restoration damages represent the costs to restore Feature 17 once the lake levels recede after a period of flooding. Restoration damages include rebuilding the road with excavation, fill, surface material, and bridge repairs. Restoration damages are a per-event damage.

Unit costs for all the damage computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for US Highway 281 (North of US Highway 2) are listed in the Feature 17 Assumptions listing, appended to this Section 2.17.

Costs: The costs of providing flood protection for US Highway 281 (North of US Highway 2) are detailed in the accompanying Table 2.17-2. Unit costs, data sources, and relevant assumptions are listed.

The first portion of the table shows the cost of incremental road raises and relocation costs at each action level (1451, 1456, and 1461). Incremental road raise costs are broken down into six categories: fabric liner, aggregate base, fill, riprap, bituminous, and bridge work. Relocation assumes a per mile cost.

Unit costs for all the cost computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for US Highway 281 (North of US Highway 2) are listed in the Feature 17 Assumptions listing, appended to this Section 2.17.

2.17.4 Results of Economic Analysis

The results of the Economic Analysis for the US Highway 281 (North of US Highway 2) are listed in Table 2.17-3.

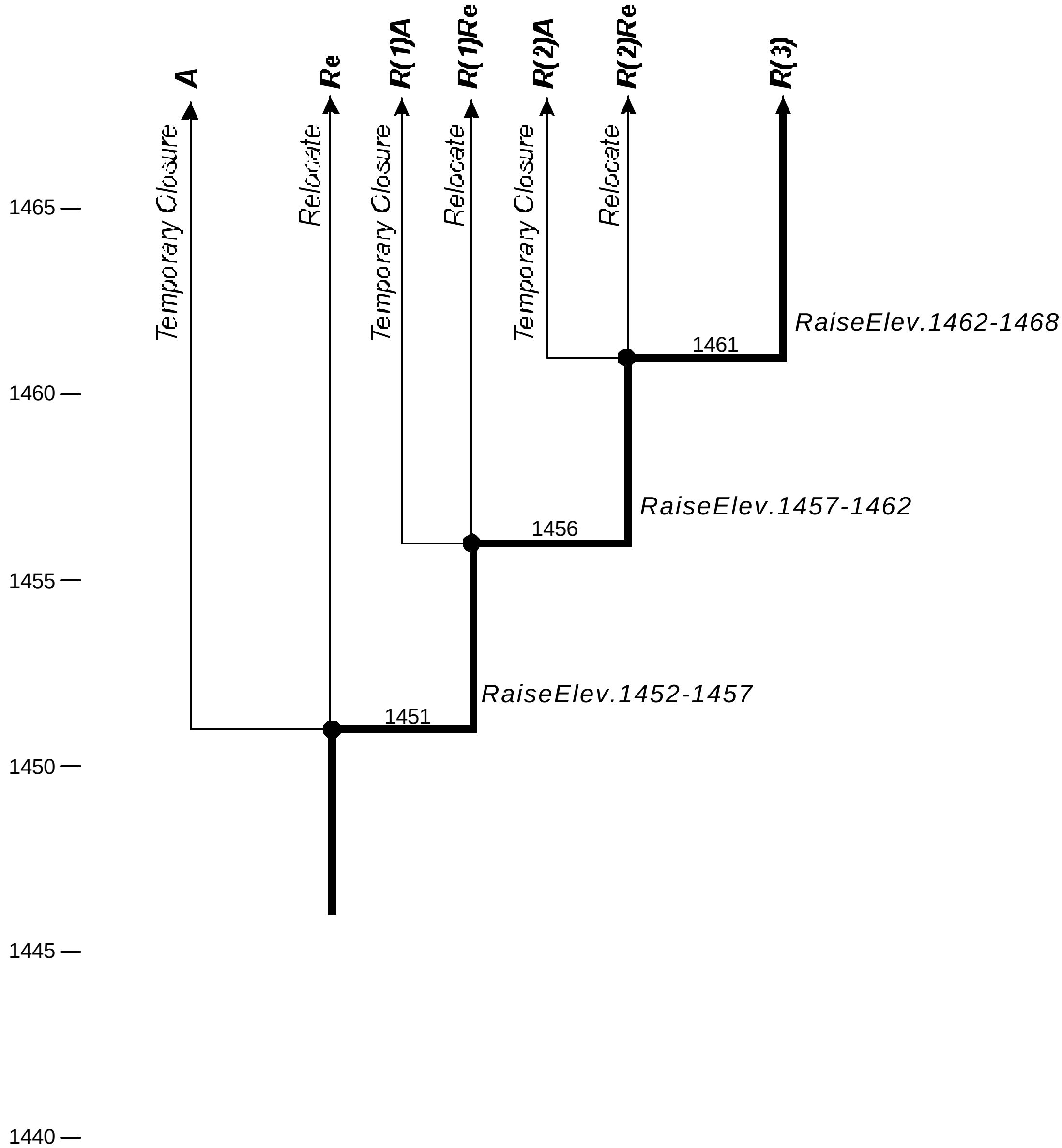
Stochastic Analysis Results: The stochastic analysis indicated that both of the protection strategies had net benefits that were less than one. The flood protection strategy with the largest net benefits was for incremental road raises. This strategy is highlighted on the decision tree (Figure 2.17-2). The average annual restoration and detour damages for this strategy were -$145,000 and the BCR was 0.53. These results indicate that this strategy was not economically justified. The present worth annualized detour damages that would be prevented by this strategy were computed to be $142,500. The stochastic results are averages over 10,000 traces.

Results for Specific Scenarios: In the economic analysis, flood protection strategies were also analyzed for three specific climate futures. For US Highway 281 (North of US Highway 2), the identified strategy and the economic indices for each of the three climate futures are as follows:

- Wet Future – For the wet future, both of the protection strategies had net benefits that were less than one. The annual net benefits for the incremental road raise strategy were -$335,100 and the BCR was 0.77. For this future, the present worth annualized detour damages that would be prevented were computed at $1,018,700.
- First Moderate Future – For the first moderate future, lake levels do not reach the first damage levels.
- Second Moderate Future – For the second moderate future, both of the protection strategies had net benefits that were less than one. The annual net benefits for the incremental road raise strategy were -$40,100 and the BCR was 0.90. For this future, the present worth annualized detour damages that would be prevented were computed at $273,800.

Figure 2.17-1
LOCATION MAP
FEATURE 17: US HIGHWAY 281
(NORTH OF US HIGHWAY 2)
Devils Lake Infrastructure
Protection Study

DATA: 1997 USGS Digital Ortho Quad



LowestRoadElevation:1452

FloodProtectionStrategy

Decisionrequiredatthispoint

Triggerpointforaction,nodecisionneeded

R(1) Incrementalroad raise(number oftimes)

A Temporary closureofroad

Re Relocate

Figure2.17-2

DECISION TREE
FEATURE 17:U.S.HIGHWAY281
(Northof U.S.Highway 2)
DevilsLakeInfrastructure ProtectionStudy

Table 2.17-1

Flood Damages
Feature 17: US Highway 281 (North of US Highway 2)
Devils Lake Infrastructure Protection Study

DAMAGES

Action Levels	Strategy	Annual Detour Damages
		(THOUSANDS)
AL1 - AL3	A - Temporary Closure at AL1	$1,322
	Re - Relocate at AL1	$1,326

DAMAGE BREAKDOWN

	AL1 - AL3				
Damage	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Annual Detour Damages	HWY 281				
	HR/YEAR	53,737	HR	$7.00	$376
	MILES/YEAR	2,955,558	MILE	$0.32	$946
	Total				**$1,322**
Annual Relocation Detour Damages	HWY 281				
	HR/YEAR	53,891	HR	$7.00	$377
	MILES/YEAR	2,964,032	MILE	$0.32	$948
	Total				**$1,326**

Restoration Damages

		Excavation				Fabric Liner				Aggregate Base Course				Fill				Bituminous Pavement				Bridge Repair			
Elevation	Total (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Cost (THOUSANDS)
1451	$0																								
1452	$897	25,000	CY	$2.65	$66	44,445	SY	$1.33	$59	5,382	CY	$21.20	$114	37,015	CY	$4.77	$177	10,083	TON	$47.70	$481	0	EA	$530,000	$0
1453	$897	25,000	CY	$2.65	$66	44,445	SY	$1.33	$59	5,382	CY	$21.20	$114	37,015	CY	$4.77	$177	10,083	TON	$47.70	$481	0	EA	$530,000	$0
1454	$897	25,000	CY	$2.65	$66	44,445	SY	$1.33	$59	5,382	CY	$21.20	$114	37,015	CY	$4.77	$177	10,083	TON	$47.70	$481	0	EA	$530,000	$0
1455	$3,774	105,200	CY	$2.65	$279	187,022	SY	$1.33	$248	22,647	CY	$21.20	$480	155,760	CY	$4.77	$743	42,341	TON	$47.70	$2,024	0	EA	$530,000	$0
1456	$3,774	105,200	CY	$2.65	$279	187,022	SY	$1.33	$248	22,647	CY	$21.20	$480	155,760	CY	$4.77	$743	42,341	TON	$47.70	$2,024	0	EA	$530,000	$0
1457	$4,834	105,200	CY	$2.65	$279	187,022	SY	$1.33	$248	22,647	CY	$21.20	$480	155,760	CY	$4.77	$743	42,341	TON	$47.70	$2,024	2	EA	$530,000	$1,060
1458	$4,834	105,200	CY	$2.65	$279	187,022	SY	$1.33	$248	22,647	CY	$21.20	$480	155,760	CY	$4.77	$743	42,341	TON	$47.70	$2,024	2	EA	$530,000	$1,060
1459	$6,634	155,400	CY	$2.65	$412	276,267	SY	$1.33	$366	33,454	CY	$21.20	$709	230,086	CY	$4.77	$1,098	62,678	TON	$47.70	$2,990	2	EA	$530,000	$1,060
1460	$6,634	155,400	CY	$2.65	$412	276,267	SY	$1.33	$366	33,454	CY	$21.20	$709	230,086	CY	$4.77	$1,098	62,678	TON	$47.70	$2,990	2	EA	$530,000	$1,060
1461	$9,665	239,880	CY	$2.65	$636	426,453	SY	$1.33	$565	51,641	CY	$21.20	$1,095	355,168	CY	$4.77	$1,694	96,752	TON	$47.70	$4,615	2	EA	$530,000	$1,060
1462	$9,665	239,880	CY	$2.65	$636	426,453	SY	$1.33	$565	51,641	CY	$21.20	$1,095	355,168	CY	$4.77	$1,694	96,752	TON	$47.70	$4,615	2	EA	$530,000	$1,060
1463	$10,224	255,480	CY	$2.65	$677	454,187	SY	$1.33	$602	54,999	CY	$21.20	$1,166	378,266	CY	$4.77	$1,804	103,044	TON	$47.70	$4,915	2	EA	$530,000	$1,060

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.

Table 2.17-2

Flood Protection Costs
Feature 17: US Highway 281 (North of US Highway 2)
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Action Level	Lake Elevation	A Temporary Closure at AL1	Re Relocate at AL1	R(1)A Raise at AL1; Temporary Closure at AL2	R(1)Re Raise at AL1; Relocate at AL2	R(2)A Raise at AL1,AL2; Temporary Closure at AL3	R(2)Re Raise at AL1,AL2; Relocate at AL3	R(3) Raise at AL1, AL2, AL3
	(MSL)	(THOUSANDS)						
AL1	1451	$0	$10,067	$12,126	$12,126	$12,126	$12,126	$12,126
AL2	1456	$0	$0	$0	$10,067	$23,537	$23,537	$23,537
AL3	1461	$0	$0	$0	$0	$0	$10,067	$38,376

COST BREAKDOWN

Strategy		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
		R(1)A / R(1)Re / R(2)A / R(2)Re / R(3)					R(2)A / R(2)Re / R(3)					R(3)				
		Lake Elevation 1451					Lake Elevation 1456					Lake Elevation 1461				
Incremental Raise																
	Road Raise	US Highway 281					US Highway 281					US Highway 281				
		Fabric Liner	239,977	SY	$1.33	$319	Fabric Liner	427,931	SY	$1.33	$569	Fabric Liner	561,680	SY	$1.33	$747
		Aggregate Base	22,647	CY	$21.20	$480	Aggregate Base	28,944	CY	$21.20	$614	Aggregate Base	13,072	CY	$21.20	$277
		Fill	380,559	CY	$9.00	$3,425	Fill	1,123,491	CY	$9.00	$10,111	Fill	2,649,751	CY	$9.00	$23,848
		Riprap	160,588	CY	$30.00	$4,818	Riprap	286,364	CY	$30.00	$8,591	Riprap	375,866	CY	$30.00	$11,276
		Bituminous	42,431	TON	$47.70	$2,024	Bituminous	54,321	TON	$47.70	$2,591	Bituminous	24,490	TON	$47.70	$1,168
		Bridge Rebuild	2	EA	$530,000	$1,060	Bridge Rebuild	2	EA	$530,000	$1,060	Bridge Rebuild	2	EA	$530,000	$1,060
		Total				**$12,126**	**Total**				**$23,537**	**Total**				**$38,376**
		Re					R(1)Re					R(2)Re				
Relocation		Reroute Path: BC 28, BC 25, US 2					Reroute Path: BC 28, BC 25, US 2					Reroute Path: BC 28, BC 25, US 2				
	Reroute	Upgrade BC 28, BC 25					Upgrade BC 28, BC 25					Upgrade BC 28, BC 25				
			14.5 MILE	MILE	$694,300	$10,067		14.5	MILE	$694,300	$10,067		14.5	MILE	$694,300	$10,067
		Total				**$10,067**	**Total**				**$10,067**	**Total**				**$10,067**

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.

Table 2.17 - 3

Economic Analysis of Strategies for Highway 281 North of US Highway 2

(Feature 17)

Stochastic Analysis (ST) — Mean Value over 10,000 Traces (Annual)

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C*
A	Temporary Closure During Floods at First Action Level	$0	$0	$0	$21,000	$142,500	$0	$163,600	$0	$0	--
Re	Relocation of Road at First Action Level	$0	$132,700	$132,700	$0	$0	$265,900	$265,900	-$102,300	-$235,000	-0.77
R(1)A	1 Road Raise: Then Temporary Closure During Floods	$159,800	$0	$159,800	$19,900	$42,700	$0	$62,600	$100,900	-$58,900	0.63
R(2)A	2 Road Raises: Then Temporary Closure During Floods	$266,900	$0	$266,900	$9,400	$4,700	$0	$14,000	$149,500	-$117,300	0.56
R(1)Re	1 Road Raise: Then Relocate	$159,800	$45,800	$205,600	$0	$0	$89,900	$89,900	$73,700	-$132,000	0.36
R(2)Re	2 Road Raises: Then Relocate	$266,900	$11,000	$277,800	$0	$0	$21,200	$21,200	$142,300	-$135,500	0.51
R(3)	3 Incr. Road Raises	$308,600	$0	$308,600	$0	$0	$0	$0	$163,600	-$145,000	0.53

Wet Future Scenario (WF) (Annual)

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C*
A	Temporary Closure During Floods at First Action Level	$0	$0	$0	$88,200	$1,018,700	$0	$1,106,800	$0	$0	--
Re	Relocation of Road at First Action Level	$0	$493,600	$493,600	$0	$0	$1,021,700	$1,021,700	$85,100	-$408,500	0.17
R(1)A	1 Road Raise: Then Temporary Closure During Floods	$594,600	$0	$594,600	$108,400	$623,700	$0	$732,100	$374,700	-$219,900	0.63
R(2)A	2 Road Raises: Then Temporary Closure During Floods	$1,442,000	$0	$1,442,000	$0	$0	$0	$0	$1,106,800	-$335,100	0.77
R(1)Re	1 Road Raise: Then Relocate	$594,600	$362,400	$957,000	$0	$0	$733,300	$733,300	$373,500	-$583,500	0.39
R(2)Re	2 Road Raises: Then Relocate	$1,442,000	$0	$1,442,000	$0	$0	$0	$0	$1,106,800	-$335,100	0.77
R(3)	3 Incr. Road Raises	$1,442,000	$0	$1,442,000	$0	$0	$0	$0	$1,106,800	-$335,100	0.77

Moderate Future 1 Scenario (M1) (Annual)

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C*
A	Temporary Closure During Floods at First Action Level	$0	$0	$0	$0	$0	$0	$0	$0	$0	--
Re	Relocation of Road at First Action Level	$0	$0	$0	$0	$0	$0	$0	$0	$0	--
R(1)A	1 Road Raise: Then Temporary Closure During Floods	$0	$0	$0	$0	$0	$0	$0	$0	$0	--
R(2)A	2 Road Raises: Then Temporary Closure During Floods	$0	$0	$0	$0	$0	$0	$0	$0	$0	--
R(1)Re	1 Road Raise: Then Relocate	$0	$0	$0	$0	$0	$0	$0	$0	$0	--
R(2)Re	2 Road Raises: Then Relocate	$0	$0	$0	$0	$0	$0	$0	$0	$0	--
R(3)	3 Incr. Road Raises	$0	$0	$0	$0	$0	$0	$0	$0	$0	--

Moderate Future 2 Scenario (M2) (Annual)

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C*
A	Temporary Closure During Floods at First Action Level	$0	$0	$0	$71,900	$273,800	$0	$345,700	$0	$0	--
Re	Relocation of Road at First Action Level	$0	$320,300	$320,300	$0	$0	$640,700	$640,700	-$295,000	-$615,300	-0.92
R(1)A	1 Road Raise: Then Temporary Closure During Floods	$385,800	$0	$385,800	$0	$0	$0	$0	$345,700	-$40,100	0.90
R(2)A	2 Road Raises: Then Temporary Closure During Floods	$385,800	$0	$385,800	$0	$0	$0	$0	$345,700	-$40,100	0.90
R(1)Re	1 Road Raise: Then Relocate	$385,800	$0	$385,800	$0	$0	$0	$0	$345,700	-$40,100	0.90
R(2)Re	2 Road Raises: Then Relocate	$385,800	$0	$385,800	$0	$0	$0	$0	$345,700	-$40,100	0.90
R(3)	3 Incr. Road Raises	$385,800	$0	$385,800	$0	$0	$0	$0	$345,700	-$40,100	0.90

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.375% and rounded to the nearest $100.
* Total benefits are calculated as the total damages incurred for "temporary closure strategy" minus the total damages for the strategy implemented (G(S) In some cases this results in negative total benefits, and causes a seemingly erroneous negative sign to appear in the BCR.
The "No Protection" strategy for roads has been defined as temporary closure during floods at the first action level with restoration when the lake recedes.

Attachment to 2.17:
US Highway 281 (North of US Highway 2) Economic Analysis Assumptions

No feature-specific assumptions were made for Feature 17.

A. General Assumptions

1. Decisions were assumed to occur when the lake level is within (or predicted by the National Weather Service to be within) 1 foot of the lowest road elevation. This assumption is consistent with current practices in the area as dictated by funding agencies. In the past, funding for road raises has not been

   water during that year.

2. If the road includes a bridge having a low chord elevation below the lowest road elevation, it was assumed that no decision would occur until the lake level was within 1 foot of the lowest road elevation. This assumption follows current practices in the area.

B. Road Raises

1. Road raise costs were calculated in the manner presented in a previous study (*Devils Lake Flood Control: Economics Database Update: Transportation Report*, Barr Engineering Company, January 1998). Unit costs for construction materials were updated for inflation by multiplying them by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001. Additionally the cost of riprap and fill were increased from $20 to $30 and $4.50 to $9.00, respectively. Based on conversations with the NDDOT, railroad companies, and the Corps of Engineers the new costs for riprap and fill are more representative of the costs in the area.

2. The last road raise was assumed to be to elevation 1468. At this elevation, roads would be 5 feet above the assumed maximum lake level (elevation 1463).

3. The final incremental road raise (to elevation 1468) was assumed to be no more than 8 feet and no less than 4 feet.

C. Temporary Road Closure During Floods

1. It was assumed that if a road was temporarily closed, it would be restored after the lake level has receded 1 foot below the top of road. All of the road features in this study are highly traveled. It is very likely that people would want to use these roads again if the lake level receded after flooding, assuming that communities, businesses, farmsteads, and residents continue to generate the same level of traffic as at present.

2. Restoration damages were calculated in the manner presented in *Devils Lake Flood Control: Economics Database Update: Transportation Report,* Barr Engineering Company, January 1998. Unit costs for construction materials were updated for inflation by multiplying them by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001.

3. Detour damages were included for every year that a road is temporarily closed, as well as for the first year that the lake has receded. It was assumed that during the first year after the lake has receded, the road would be under restoration. During this first year, there would be both a detour damage and restoration damage. After this first year, there would be no further detour or restoration damages unless the lake rises to within 1 foot of the road again.

4. Restoration of a road would only occur after the lake has receded to 1 foot below the lowest elevation in that road. This was based on the assumption that restoration would only occur when there is no water on any part of the road and there would be only minor potential for wave action damage on the road.

5. Detour damages were calculated using a cost of $7 per hour of additional travel time, 1.5 people per vehicle, and $0.32 per mile for additional travel distance (Corps of Engineers, March, 2001). Additional time and miles traveled were taken from the results of the QRS II model used in *Devils Lake Flood Control: Economics Database Update: Transportation Report,* Barr Engineering Company, January 1998. The QRS II model determines the overall effect of a closed road on an entire network of traffic, incorporating the fact that traffic consists of trips having different origins and destinations.

6. Two features can have mutually interdependent detour routes if they are the most reasonable detours. In these cases, it was assumed that either the analyzed feature or the other feature would be raised or rerouted. In these cases, the interdependency was noted.

D. Road Reroutes

1. It was assumed that if a road was permanently rerouted, the old route for that road would never be restored. Rerouting a road is an expensive option, so it was assumed that once this investment was made, the old road would not be considered usable. However, detour damages (reflecting the longer distance on the new alignment) will continue to be incurred for every year that the rerouted road is in use. This detour damage is estimated with same model output from the QRS II model described in the assumptions regarding temporary closure during flooding.

2. It was assumed that the rerouted path for any feature would be upgraded to the same level (road width and speed limit) as the existing feature.

3. Road reroutes do not necessarily have to be onto roads that are currently at or above the maximum elevation 1468. If there is a logical reroute path that would require a minor road lift (<10 feet), this reroute path could still be acceptable.

4. The only features that have reroute strategies are Highway 281 north of US Highway 2, and Highway 281 south of US Highway 2. All other strategies either have no logical reroute or have routes that would require more than 10-foot raises.

2.18 Summary of Economic Analysis Investigation for Feature 18: ND Highway 19

2.18.0 Flood Protection Strategy

The flood protection strategy that was analyzed in the Economic Analysis of Devils Lake Alternatives for ND Highway 19 was incremental road raises.

2.18.1 General Information

Feature Type: Road

Location: ND Highway 19 is located in Creel North, Grand Harbor, Pelican, Riggin East and Riggin West Townships, Benson County. The feature extends approximately 16 miles between US Highway 281 at the west to the City of Devils Lake at the east. The accompanying Figure 2.18-1 shows the feature's location and extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: ND Highway 19 is a two-lane bituminous-surfaced state highway. The centerline elevation is, at it's lowest, 1448. The portions of this feature below 1455 are planned to be raised to 1455 in 2001, according to ND DOT sources. Bridges will be raised to road surface elevation 1465 with low chord at 1461.

Significance: ND Highway 19 is important because it is a major east/west arterial route through the Devils Lake region and provides a primary route between the Minnewaukan area and the City of Devils Lake.

Damages: The flooding of ND Highway 19 would result in the following damages:

- Detour damages resulting from the added travel time and miles traveled when ND Highway 19 is closed and traffic is detoured
- Restoration damages resulting from repairs that would be necessary to bring the highway back to a useable condition after a period of inundation

Owner/Sponsor: The North Dakota Department of Transportation is responsible for managing and maintaining ND Highway 19.

Lead Federal Agency: The Federal Highway Administration would take the lead for ND Highway 19 in any flood protection work that may take place.

2.18.2 Feature Protection

History of Flood Protection: In the past, flood protection for ND Highway 19 has consisted of raising the road to keep it from being overtopped. The most recent raise of ND Highway 19 occurred in 1997 when four separate areas of the road were raised to 1448. The raise locations were near Creel Bay, across Six-Mile Bay, near Mavauis Coulee and the US Highway 281 and ND Highway 19 junction.

General Protection Strategy: The analysis identified and evaluated one approach for protecting ND Highway 19: raising the road.

Protection Strategy by Lake Level: The Economic Analysis of Devils Lake Alternatives considered various protection strategies, with flood protection decisions being made at various lake levels as Devils Lake continued to rise. Figure 2.18-2 shows the decision tree for ND Highway 19. As shown on Figure 2.18-2, the stepwise approach to flood protection for ND Highway 19 that was analyzed consisted of the following:

1. At lake elevation 1454, a decision would be made as to whether the road would be raised to 1460, or temporarily closed.
2. If the road were raised at the first action level, at lake elevation 1459 another decision would be made as to whether the road would be raised to 1468, or temporarily closed.

The maximum protection strategy that was analyzed at the first action level was raising the road to 1468. (Note that for the analysis, the decision regarding whether or not to raise the road is made at a time when the lake is one foot below the minimum highway elevation that resulted from the most recent raise.)

Interdependencies: The protection of ND Highway 19 is related to the protection of several other features:

- Feature 7: Grahams Island State Park – ND Highway 19 is the primary route to Feature 7, so closure or rerouting on ND Highway 19 would impact decisions regarding the protection strategy for Feature 7.
- Feature 13: US Highway 2 – If ND Highway 19 were temporarily closed, traffic on Feature 13 would increase because it is an alternate east-west route to US Highway 281.
- Feature 14: ND Highway 57 (between ND Highway 20 and BIA Highway 1) – If ND Highway 19 were temporarily closed, traffic on ND Highway 57 would increase because it is an alternate east-west route to US Highway 281(and vice versa).

- Feature 15: ND Highway 57 (between BIA Highway 1 and US Hwy 281) – If ND Highway 19 were temporarily closed, traffic on ND Highway 57 would increase because it is an alternate east-west route to US Highway 281 (and vice versa).
- Feature 16: US Highway 281 (South of US Highway 2) – These highways intersect and together provide a major transportation route around the lake, between Minnewaukan and the City of Devils Lake. Therefore, if either highway were temporarily closed, traffic on the other highway would be reduced, as traffic would be detoured on another route around the lake.
- Feature 21: ND Highway 20 (City of Devils Lake Levee to ND Highway 57) – If ND Highway 20 temporarily closes (cutting off access across the lake), traffic would be routed around the lake on ND Highway 19.

Table 2.0-1, mentioned earlier in this report, provides a summary of the interdependencies among the features.

2.18.3 Feature Economics

Damages: For ND Highway 19, the damages resulting from flooding were estimated up to the maximum lake level (1463). The damage computations for ND Highway 19 are summarized in the accompanying Table 2.18-1.

The top portion of Table 2.18-1 gives a summary of the annual detour damages that would occur during the years when the highway was flooded. It also shows road restoration damages that can be expected when the lake recedes. Restoration damages include rebuilding the road with excavation, fill, surface material, and bridge repairs. Restoration damages are a per-event damage.

The lower portion of the table shows the breakdown of these summary values for each of the three action levels. It gives quantities in terms of miles per year (of extra miles traveled as a result of detours) and hours per year (of additional travel time resulting from detours) for the detour damages. Also shown are quantities and line-item damages for excavation, fabric liner, aggregate base course, and fill for road restoration work when waters recede.

Unit prices for all the damage computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for ND Highway 19 are listed in the Feature 18 Assumptions listing, appended to this Section 2.18.

Costs: The costs of providing flood protection for ND Highway 19 are detailed in the accompanying Table 2.18-2. Quantities and line-item totals are listed.

The top portion of the table gives the costs of providing flood protection (as represented in the analysis) by action level for all of the flood protection strategies. The lower portion of the table gives a breakdown of the quantities and costs by line item: fabric liner, aggregate base, fill, riprap, and bituminous pavement material.

Unit costs for all the cost computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for ND Highway 19 are listed in the Feature 18 Assumptions listing, appended to this Section 2.18.

2.18.4 Results of Economic Analysis

The results of the Economic Analysis for the ND Highway 19 are listed in Table 2.18-3.

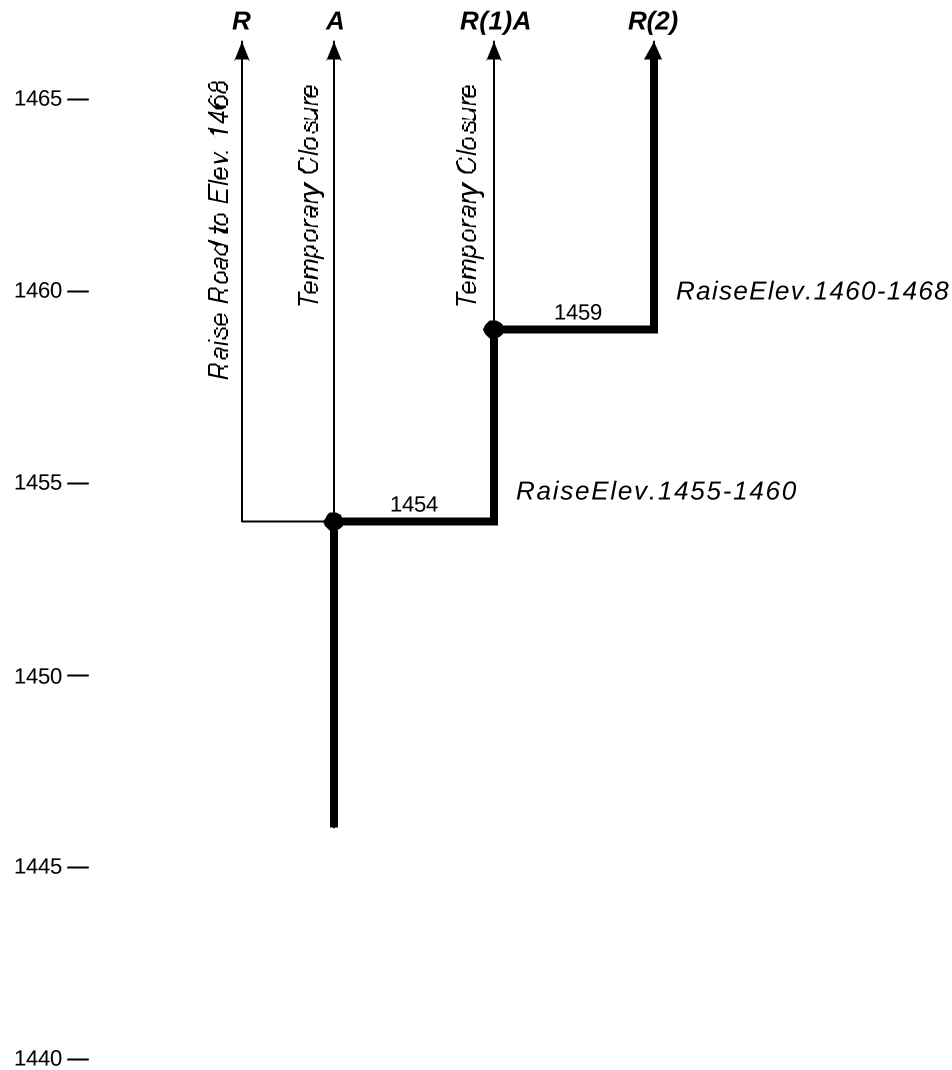
Stochastic Analysis Results: The flood protection strategy that was analyzed for protecting ND Highway 19 was two incremental road raises. This strategy is highlighted on the decision tree (Figure 2.18-2). The average annual net benefits for this strategy were less than zero (-$291,900). The BCR for this strategy was less than one (0.29). These results indicate that this strategy was not economically justified. The present worth annualized detour damages that would be prevented by this strategy were computed to be $70,100. The stochastic results are averages over 10,000 traces.

Results for Specific Scenarios: In the economic analysis, flood protection strategies were also analyzed for three specific climate futures. For ND Highway 19, the identified strategy and the economic indices for each of the three climate futures are as follows:

- Wet Future – For the wet future, the annual net benefits were -$2,421,000, and the BCR was 0.27, indicating that this strategy was not economically justified. For this future, the present worth annualized detour damages that would be prevented were computed at $768,400.
- First Moderate Future – For the first moderate future, lake levels do not reach the first damage levels.
- Second Moderate Future – For the second moderate future, the annual net benefits were -$753,600, and the BCR was 0.35, indicating that this strategy was not economically justified. For this future, the present worth annualized detour damages that would be prevented were computed at $175,400.

DATA: 1997 USGS Digital Ortho Quad

Barr: Arcview 3.1, PIIIAF, i:\client\devilslake\gis\dlip\features\roadandrails\roads\18_hwy19\project\basemap_18.apr, Layout: Section 2 ND Highway 19 , lkp, Tue Oct 29 15:58:33 2002



LowestRoadElevation:1455

(thick line)	FloodProtectionStrategy
●	Decisionrequiredatthispoint
⨀	Triggerpointforaction,nodecisionneeded
R(1)	Incrementalroad raise(number oftimes)
R	Road raiseto1468
A	Temporary closureofroad

Figure2.18-2

DECISION TREE
FEATURE 18:NDHIGHWAY19
DevilsLakeInfrastructure ProtectionStudy

Table 2.18-1

Flood Damages
Feature 18: ND Highway 19
Devils Lake Infrastructure Protection Study

DAMAGES

Action Levels	Annual Detour Damages (THOUSANDS)
AL1 - AL2	$1,322

DAMAGE BREAKDOWN

	AL1 - AL2				
Damage	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Annual Detour Damages	ND HWY 19				
	HR/YEAR	53,737	HR	$7.00	$376
	MILES/YEAR	2,955,558	MILE	$0.32	$946
	Total				$1,322

Restoration Damages

		Excavation				Fabric Liner				Aggregate Base Course			
Elevation	Total (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)
1454	$0												
1455	$9,923	276,640	CY	$2.65	$733	489,956	SY	$1.33	$652	59,554	CY	$21.20	$1,263
1456	$9,923	276,640	CY	$2.65	$733	489,956	SY	$1.33	$652	59,554	CY	$21.20	$1,263
1457	$9,923	276,640	CY	$2.65	$733	489,956	SY	$1.33	$652	59,554	CY	$21.20	$1,263
1458	$9,923	276,640	CY	$2.65	$733	489,956	SY	$1.33	$652	59,554	CY	$21.20	$1,263
1459	$9,923	276,640	CY	$2.65	$733	489,956	SY	$1.33	$652	59,554	CY	$21.20	$1,263
1460	$11,258	313,840	CY	$2.65	$832	555,841	SY	$1.33	$739	67,563	CY	$21.20	$1,432
1461	$12,015	334,960	CY	$2.65	$888	593,246	SY	$1.33	$789	72,109	CY	$21.20	$1,529
1462	$14,999	356,080	CY	$2.65	$944	630,651	SY	$1.33	$839	76,656	CY	$21.20	$1,625
1463	$15,272	363,680	CY	$2.65	$964	644,111	SY	$1.33	$857	78,292	CY	$21.20	$1,660

	Fill				Bituminous Pavement				Bridge Repair			
Elevation	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Cost (THOUSANDS)
1454												
1455	409,595	CY	$4.77	$1,954	111,578	TON	$47.70	$5,322	0	EA	$530,000	$0
1456	409,595	CY	$4.77	$1,954	111,578	TON	$47.70	$5,322	0	EA	$530,000	$0
1457	409,595	CY	$4.77	$1,954	111,578	TON	$47.70	$5,322	0	EA	$530,000	$0
1458	409,595	CY	$4.77	$1,954	111,578	TON	$47.70	$5,322	0	EA	$530,000	$0
1459	409,595	CY	$4.77	$1,954	111,578	TON	$47.70	$5,322	0	EA	$530,000	$0
1460	464,674	CY	$4.77	$2,216	126,582	TON	$47.70	$6,038	0	EA	$530,000	$0
1461	495,944	CY	$4.77	$2,366	135,101	TON	$47.70	$6,444	0	EA	$530,000	$0
1462	527,215	CY	$4.77	$2,515	143,619	TON	$47.70	$6,851	2	EA	$530,000 / $2,226,000	$2,226
1463	538,468	CY	$4.77	$2,568	146,684	TON	$47.70	$6,997	2	EA	$530,000 / $2,226,000	$2,226

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.

Table 2.18-2

Flood Protection Costs
Feature 18: ND Highway 19
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Action Level	Lake Elevation	R Maximum Raise at AL1	A Temporary Closure at AL1	R(1)A Raise at AL1; Temporary Closure at AL2	R(2) Raise at AL1, AL2
	(MSL)	(THOUSANDS)			
AL1	1454	$101,252	$0	$38,810	$38,810
AL2	1459	$0	$0	$0	$62,442

COST BREAKDOWN

		R									
		R(1)A									
		R(2)					R(2)				
		Lake Elevation 1454					Lake Elevation 1459				
Strategy		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Incremental Raise											
	Road Raise	ND Highway 19					ND Highway 19				
		Fabric Liner	808,967	SY	$1.33	$1,076	Fabric Liner	875,645	SY	$1.33	$1,165
		Aggregate Base	67,563	CY	$21.20	$1,432	Aggregate Base	10,729	CY	$21.20	$227
		Fill	1,558,181	CY	$9.00	$14,024	Fill	4,605,879	CY	$9.00	$41,453
		Riprap	541,346	CY	$30.00	$16,240	Riprap	585,966	CY	$30.00	$17,579
		Bituminous	126,582	TON	$47.70	$6,038	Bituminous	20,102	TON	$47.70	$959
		Bridge Rebuild	0	EA	$530,000	$0	Bridge Rebuild	2	EA	$530,000	$1,060
		Total				**$38,810**	**Total**				**$62,443**
							2001 Adjusted Total				**$62,442**

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. The costs for the Maximum Raise at AL1 strategy (R) is equal to the sum of the costs for all incremental raises.
4. 2001 Adjusted Total adjusts detailed cost breakdown to match the 2001 totals.

Table 2.18 - 3

Economic Analysis of Strategies for Highway 19 from the City of Devils Lake Levee to Highway 281 (Feature 18)

Stochastic Analysis (ST)
Mean Value over 10,000 Traces (Annual)

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Le	$0	$0	$0	$49,600	$70,100	$0	$119,600	$0	$0	--
R	Road Raise to 1468	$694,500	$0	$694,500	$0	$0	$0	$0	$119,600	-$574,900	0.17
R(1)A	1 Road Raise: Then Temporary Closure During Flo	$266,200	$0	$266,200	$22,900	$16,400	$0	$39,300	$80,300	-$185,900	0.30
R(2)	2 Incr. Road Raises	$411,600	$0	$411,600	$0	$0	$0	$0	$119,600	-$291,900	0.29

Wet Future Scenario (WF)
(Annual)

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Le	$0	$0	$0	$147,300	#######	$0	$915,700	$0	$0	--
R	Road Raise to 1468	########	$0	$4,124,800	$0	$0	$0	$0	$915,700	-$3,209,100	0.22
R(1)A	1 Road Raise: Then Temporary Closure During Flo	########	$0	$1,581,000	$166,800	#######	$0	$491,600	$424,000	-$1,157,000	0.27
R(2)	2 Incr. Road Raises	########	$0	$3,336,600	$0	$0	$0	$0	$915,700	-$2,421,000	0.27

Moderate Future 1 Scenario (M1)
(Annual)

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Le	$0	$0	$0	$0	$0	$0	$0	$0	$0	--
R	Road Raise to 1468	$0	$0	$0	$0	$0	$0	$0	$0	$0	--
R(1)A	1 Road Raise: Then Temporary Closure During Flo	$0	$0	$0	$0	$0	$0	$0	$0	$0	--
R(2)	2 Incr. Road Raises	$0	$0	$0	$0	$0	$0	$0	$0	$0	--

Moderate Future 2 Scenario (M2)
(Annual)

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Le	$0	$0	$0	$231,800	#######	$0	$407,100	$0	$0	--
R	Road Raise to 1468	########	$0	$3,028,300	$0	$0	$0	$0	$407,100	-$2,621,100	0.13
R(1)A	1 Road Raise: Then Temporary Closure During Flo	########	$0	$1,160,700	$0	$0	$0	$0	$407,100	-$753,600	0.35
R(2)	2 Incr. Road Raises	########	$0	$1,160,700	$0	$0	$0	$0	$407,100	-$753,600	0.35

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.375% and rounded to the nearest $100.
* Total benefits are calculated as the total damages incurred for "temporary closure strategy" minus the total damages for the strategy implemented (G(S)).
The "No Protection" strategy for roads has been defined as temporary closure during floods at the first action level with restoration when the lake recedes.

Attachment to 2.18:
ND Highway 19 Economic Analysis Assumptions

1. Plans for 2001 include raising Highway 19 to a minimum elevation of 1455 and the bridges at Mauvais Coulee and Six Mile Bay to a minimum elevation of 1461 (low chord). For this analysis, the work was assumed completed and the new elevations were used.

A. General Assumptions

1. Decisions were assumed to occur when the lake level is within (or predicted by the National Weather Service to be within) 1 foot of the lowest road elevation. This assumption is consistent with current practices in the area as dictated by funding agencies. In the past, funding for road raises has not been available until the National Weather Service predicts on February 15th that the road will go under water during that year.

2. If the road includes a bridge having a low chord elevation below the lowest road elevation, it was assumed that no decision would occur until the lake level was within 1 foot of the lowest road elevation. This assumption follows current practices in the area.

B. Road Raises

1. Road raise costs were calculated in the manner presented in a previous study (*Devils Lake Flood Control: Economics Database Update: Transportation Report,* Barr Engineering Company, January 1998). Unit costs for construction materials were updated for inflation by multiplying them by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001. Additionally the cost of riprap and fill were increased from $20 to $30 and $4.50 to $9.00, respectively. Based on conversations with the NDDOT, railroad companies, and the Corps of Engineers the new costs for riprap and fill are more representative of the costs in the area.

2. The last road raise was assumed to be to elevation 1468. At this elevation, roads would be 5 feet above the assumed maximum lake level (elevation 1463).

3. The final incremental road raise (to elevation 1468) was assumed to be no more than 8 feet and no less than 4 feet.

C. Temporary Road Closure During Floods

1. It was assumed that if a road was temporarily closed, it would be restored after the lake level has receded 1 foot below the top of road. All of the road features in this study are highly traveled. It is very likely that people would want to use these roads again if the lake level receded after flooding, assuming that communities, businesses, farmsteads, and residents continue to generate the same level of traffic as at present.

2. Restoration damages were calculated in the manner presented in *Devils Lake Flood Control: Economics Database Update: Transportation Report,* Barr Engineering Company, January 1998. Unit costs for construction materials were updated for inflation by multiplying them by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001.

3. Detour damages were included for every year that a road is temporarily closed, as well as for the first year that the lake has receded. It was assumed that during the first year after the lake has receded, the road would be under restoration. During this first year, there would be both a detour damage and restoration damage. After this first year, there would be no further detour or restoration damages unless the lake rises to within 1 foot of the road again.

4. Restoration of a road would only occur after the lake has receded to 1 foot below the lowest elevation in that road. This was based on the assumption that restoration would only occur when there is no water on any part of the road and there would be only minor potential for wave action damage on the road.

5. Detour damages were calculated using a cost of $7 per hour of additional travel time, 1.5 people per vehicle, and $0.32 per mile for additional travel distance (Corps of Engineers, March, 2001). Additional time and miles traveled were taken from the results of the QRS II model used in *Devils Lake Flood Control: Economics Database Update: Transportation Report,* Barr Engineering Company, January 1998. The QRS II model determines the overall effect of a closed road on an entire network of traffic, incorporating the fact that traffic consists of trips having different origins and destinations.

6. There is more commitment on the part of the North Dakota Department of Transportation (NDDOT) to the Highway 57 causeway than to the Highway 20 causeway through The Narrows. Therefore, Highway 57 was assumed to be the detour route for the Highway 20 causeway. If the Highway 57 causeway was temporarily closed during flooding, it was assumed that the Highway 20 causeway would also be temporarily closed.

7. The detour route for Highway 57 is around the lake to the west via Highway 281 and Highway 19. Woods-Rutten Road was considered as a detour route for Highway 57, but it was not retained as a viable alternative, because it would have to be significantly raised and improved to carry the traffic of Highway 57.

8. Detour paths were determined assuming that all other featured roads would be open (with three exceptions: the Highway 57 detour assumes that Highway 20 across The Narrows is closed and both the BIA 1 and the BIA 6 detours assume that Highway 20 from Highway 57 to Tokio is closed). No

effort was made to link detour routes with lake level. However, if a featured road was presented as a detour route, an "interdependency" was noted.

9. Two features can have mutually interdependent detour routes if they are the most reasonable detours. In these cases, it was assumed that either the analyzed feature or the other feature would be raised or rerouted. In these cases, the interdependency was noted.

D. Road Reroutes

1. This feature had no logical reroute due to the close proximity of US Highway 2, where traffic would likely be detoured during periods of temporary closure.

2.19 Summary of Economic Analysis Investigation for Feature 19: ND Highway 1

2.19.0 Flood Protection Strategy

ND Highway 1 was being relocated when the Economic Analysis of Devils Lake Alternatives was conducted. Therefore, no further analysis was done for this feature and it was not included in the Economic Analysis.

2.19.1 General Information

Feature Type: Road

Location: Feature 19 is the portion of ND Highway 1 in Nelson County that begins at the southern ends of Sections 15 and 16 in Wamduska Township, and continues south to the southern end of the border between Sections 34 and 35. It extends approximately 3.4 miles across this stretch. The accompanying Figure 2.19-1 shows the feature's location and approximate extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: ND Highway 1 in Wamduska Township is a two-lane bituminous-surfaced state highway. Prior to the raise, the centerline elevation ranged from 1410 just east of the easternmost part of Stump Lake to 1503 approximately 3 miles south of Stump Lake. The minimum elevation of the road after the relocation was planned to be 1465.

Significance: This portion of ND Highway 1 is important because it is a major north-south traffic route for the area east of Devils Lake and Stump Lake. It is vital to serving local transportation, agricultural needs, and moving products through the area.

Damages: The flooding of Feature 19 would result in the following damages:

- Detour damages resulting from the added travel time and miles traveled when ND Highway 1 is closed and traffic is detoured
- Restoration damages resulting from repairs that would be necessary to bring the highway back to a useable condition after a period of inundation

Owner/Sponsor: The North Dakota Department of Transportation is responsible for managing and maintaining ND Highway 1.

Lead Federal Agency: The Federal Highway Administration would take the lead for ND Highway 1 for any flood protection work that may take place.

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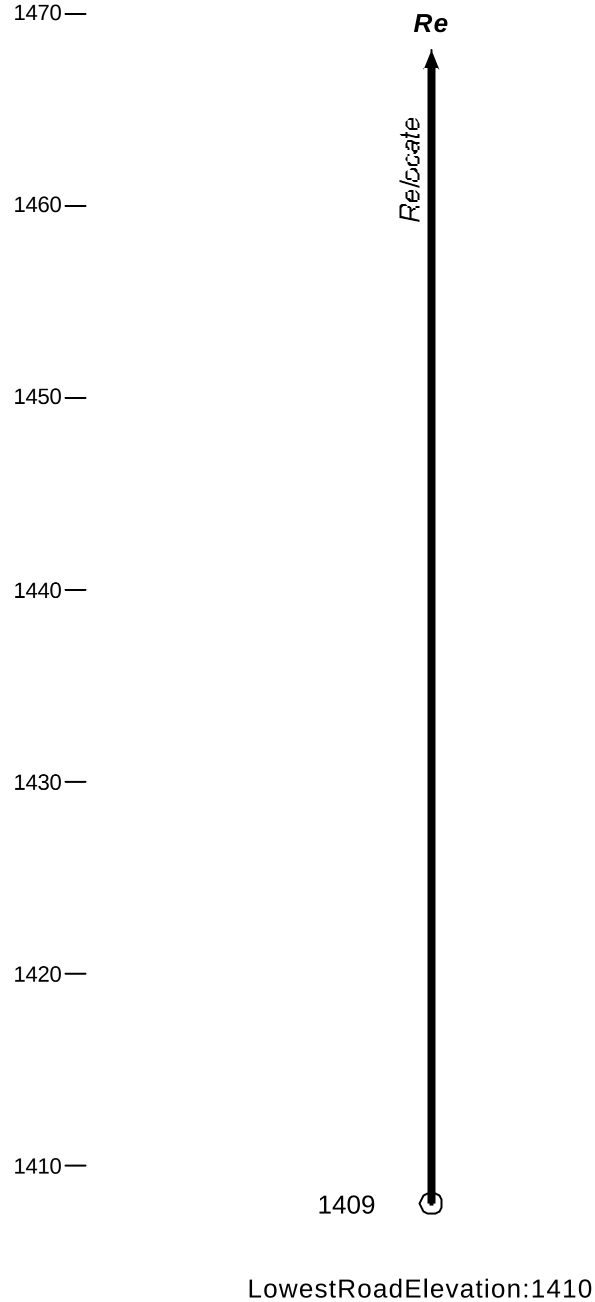
DATA: 1997 USGS Digital Ortho Quad



Flood Protection Strategy

Decision required at this point

Trigger point for action, no decision needed

Re Relocate

A Temporary closure of road

Figure 2.19-2

DECISION TREE
FEATURE 19: ND HIGHWAY 1
Devils Lake Infrastructure Protection Study

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Table 2.19-1

Flood Damages
Feature 19: ND Highway 1
Devils Lake Infrastructure Protection Study

DAMAGES

Action Level	Lake Elevation	Annual Detour Damages
	(MSL)	(THOUSANDS)
AL1	1409	$0

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.

Table 2.19-2

Flood Protection Costs
Feature 19: ND Highway 1
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Action Level	Lake Elevation	Re Relocation at AL1
	(MSL)	(THOUSANDS)
AL1	1409	$0

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.

Attachment to 2.19:
ND Highway 1 Economic Analysis Assumptions

1. Plans for 2001 include relocating Highway 1 to the east. For this analysis, the work was assumed completed and no costs or damages were associated with this feature.

A. General Assumptions

1. Decisions were assumed to occur when the lake level is within (or predicted by the National Weather Service to be within) 1 foot of the lowest road elevation. This assumption is consistent with current practices in the area as dictated by funding agencies. In the past, funding for road raises has not been available until the National Weather Service predicts on February 15th that the road will go under water during that year.

2. If the road includes a bridge having a low chord elevation below the lowest road elevation, it was assumed that no decision would occur until the lake level was within 1 foot of the lowest road elevation. This assumption follows current practices in the area.

B. Road Raises

1. Road raise costs were calculated in the manner presented in a previous study (*Devils Lake Flood Control: Economics Database Update: Transportation Report,* Barr Engineering Company, January 1998). Unit costs for construction materials were updated for inflation by multiplying them by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001. Additionally the cost of riprap and fill were increased from $20 to $30 and $4.50 to $9.00, respectively. Based on conversations with the
Engineers the new costs for riprap and fill are more representative of the costs in the area.

2. The last road raise was assumed to be to elevation 1468. At this elevation, roads would be 5 feet above the assumed maximum lake level (elevation 1463).

3. The final incremental road raise (to elevation 1468) was assumed to be no more than 8 feet and no less than 4 feet.

C. Temporary Road Closure During Floods

1. It was assumed that if a road was temporarily closed, it would be restored after the lake level has receded 1 foot below the top of road. All of the road features in this study are highly traveled. It is very likely that people would want to use these roads again if the lake level receded after flooding, assuming that communities, businesses, farmsteads, and residents continue to generate the same level of traffic as at present.

2. Restoration damages were calculated in the manner presented in *Devils Lake Flood Control: Economics Database Update: Transportation Report,* Barr Engineering Company, January 1998. Unit costs for construction materials were updated for inflation by multiplying them by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001.

3. Detour damages were included for every year that a road is temporarily closed, as well as for the first year that the lake has receded. It was assumed that during the first year after the lake has receded, the road would be under restoration. During this first year, there would be both a detour damage and restoration damage. After this first year, there would be no further detour or restoration damages unless the lake rises to within 1 foot of the road again.

4. Restoration of a road would only occur after the lake has receded to 1 foot below the lowest elevation in that road. This was based on the assumption that restoration would only occur when there is no water on any part of the road and there would be only minor potential for wave action damage on the road.

5. Detour damages were calculated using a cost of $7 per hour of additional travel time, 1.5 people per vehicle, and $0.32 per mile for additional travel distance (Corps of Engineers, March, 2001). Additional time and miles traveled were taken from the results of the QRS II model used in *Devils Lake Flood Control: Economics Database Update: Transportation Report,* Barr Engineering Company, January 1998. The QRS II model determines the overall effect of a closed road on an entire network of traffic, incorporating the fact that traffic consists of trips having different origins and destinations.

6. The detour route for Highway 57 is around the lake to the west via Highway 281 and Highway 19. Woods-Rutten Road was considered as a detour route for Highway 57, but it was not retained as a viable alternative, because it would have to be significantly raised and improved to carry the traffic of Highway 57.

7. Detour paths were determined assuming that all other featured roads would be open. No effort was made to link detour routes with lake level. However, if a featured road was presented as a detour route, an "interdependency" was noted.

8. Two features can have mutually interdependent detour routes if they are the most reasonable detours. In these cases, it was assumed that either the analyzed feature or the other feature would be raised or rerouted. In these cases, the interdependency was noted.

D. Road Reroutes

1. It was assumed that if a road was permanently rerouted, the old route for that road would never be restored. Rerouting a road is an expensive option, so it was assumed that once this investment was made, the old road would not be considered usable. However, detour damages (reflecting the longer distance on the new alignment) will continue to be incurred for every year that the rerouted road is in use. This detour damage is estimated with same model output from the QRS II model described in the assumptions regarding temporary closure during flooding.

2. It was assumed that the rerouted path for any feature would be upgraded to the same level (road width and speed limit) as the existing feature.

3. Road reroutes do not necessarily have to be onto roads that are currently at or above the maximum elevation 1468. If there is a logical reroute path that would require a minor road lift (<10 feet), this reroute path could still be acceptable.

4. The only features that have reroute strategies are Highway 281 north of US Highway 2, and Highway 281 south of US Highway 2. All other strategies either have no logical reroute or have routes that would require more than 10-foot raises.

5. Highway 1 is located near Stump Lake, which is currently at about elevation 1409. If Devils Lake overtops into Stump Lake, the lake level would rise to about elevation 1447 and become one lake with Devils Lake. It was found to be considerably less expensive to reroute Highway 1 than to raise it from 1410 to 1452. The rerouting of Highway 1 is planned for 2001. For this analysis, the reroute was assumed complete and therefore no costs or damages were associated with this feature.

2.20 Summary of Economic Analysis Investigation for Feature 20: ND Highway 20 (North of City of Devils Lake)

2.20.0 Flood Protection Strategy

The flood protection strategy that was analyzed in the Economic Analysis of Devils Lake Alternatives for ND Highway 20 (North of City of Devils Lake) was incremental road raises.

2.20.1 General Information

Feature Type: Road

Location: ND Highway 20 (North of City of Devils Lake) is located in Freshwater and Webster Townships, in Ramsey County. The feature extends from 1 mile north of Webster to 3 miles south of Webster. The accompanying Figure 2.20-1 shows the feature's location and extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: ND Highway 20 (North of City of Devils Lake) is a two-lane bituminous-surfaced state highway. The lowest centerline elevation is 1460.

Significance: ND Highway 20 (North of City of Devils Lake) is important because it is a major north/south arterial route through the Devils Lake region.

Damages: The flooding of ND Highway 20 (North of City of Devils Lake) would result in the following damages:

- Detour damages resulting from the added travel time and miles traveled when ND Highway 20 (North of City of Devils Lake) is closed and traffic is detoured
- Restoration damages resulting from repairs that would be necessary to bring the highway back to a useable condition after a period of inundation

Owner/Sponsor: The North Dakota Department of Transportation is responsible for managing and maintaining ND Highway 20 (North of City of Devils Lake).

Lead Federal Agency: The Federal Highway Administration would take the lead for ND Highway 20 (North of City of Devils Lake) in any flood protection work that may take place.

2.20.2 Feature Protection

History of Flood Protection: Flood protection for ND Highway 20 (North of City of Devils Lake) has not yet been an issue because of the high road elevation relative to historic lake levels.

General Protection Strategy: The analysis identified and evaluated one approach for protecting ND Highway 20 (North of City of Devils Lake): road raise.

Protection Strategy by Lake Level: The Economic Analysis of Devils Lake Alternatives evaluated this protection strategy, with flood protection decisions being made as Devils Lake continued to rise. Figure 2.20-2 shows the decision tree for ND Highway 20 (North of City of Devils Lake). As shown on Figure 2.20-2, the stepwise approach to flood protection for ND Highway 20 (North of City of Devils Lake) that was analyzed consisted of the following:

1. At lake elevation 1459, a decision would be made as to whether the road would be raised to 1468, or temporarily closed.

(Note that for the analysis, the decision regarding whether or not to raise the road is made at a time when the lake is one foot below the minimum highway elevation that resulted from the most recent raise.)

Interdependencies: The protection of ND Highway 20 (North of City of Devils Lake) is related to the protection of several other features:

- Feature 2: City of Devils Lake – ND Highway 20 is the main transportation route to the City of Devils Lake from the north. If ND Highway 20 (North of City of Devils Lake) were temporarily closed, traffic into and out of the City of Devils Lake would be detoured.
- Feature 13: US Highway 2 – ND Highway 20 (North of City of Devils Lake) intersects US Highway 2 in the City of Devils Lake. If either road were temporarily closed, the other road would experience increased traffic as a detour route.
- Feature 17: US Highway 281 (North of US Highway 2) – US Highway 281 and ND Highway 20 are the two main north-south routes north of US Highway 2 in the area. If either road were temporarily closed, the other road would experience increased traffic as a detour route.

Table 2.0-1, mentioned earlier in this report, provides a summary of the interdependencies among the features.

2.20.3 Feature Economics

Damages: For ND Highway 20 (North of City of Devils Lake), the damages resulting from flooding were estimated up to the maximum lake level (elevation 1463). The damage computations are summarized in the accompanying Table 2.20-1.

The top portion of Table 2.20-1 gives a summary of the annual detour damages that would occur during the years when the highway was flooded. It also shows road restoration damages that can be expected when the lake recedes. Restoration damages include rebuilding the road with excavation, fill, surface material, and bridge repairs. Restoration damages are a per-event damage.

The lower portion of the table shows the breakdown of these summary values for the action level. It gives quantities in terms of miles per year (of extra miles traveled as a result of detours) and hours per year (of additional travel time resulting from detours) for the detour damages. Also shown are quantities and line-item damages for excavation, fabric liner, aggregate base course, and fill for road restoration work when waters recede.

Unit prices for all the damage computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for ND Highway 20 (North of City of Devils Lake) are listed in the Feature 20 Assumptions listing, appended to this Section 2.20.

Costs: The costs of providing flood protection for ND Highway 20 (North of City of Devils Lake) are detailed in the accompanying Table 2.20-2. Quantities and line-item totals are listed.

The top portion of the table gives the costs of providing flood protection (as represented in the analysis) by action level for all of the flood protection strategies. The lower portion of the table gives a breakdown of the quantities and costs by line item: fabric liner, aggregate base, fill, riprap, and bituminous pavement material.

Unit costs for all the cost computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for ND Highway 20 (North of City of Devils Lake) are listed in the Feature 20 Assumptions listing, appended to this Section 2.20.

2.20.4 Results of Economic Analysis

The results of the Economic Analysis for the ND Highway 20 (North of City of Devils Lake) are listed in Table 2.20-3.

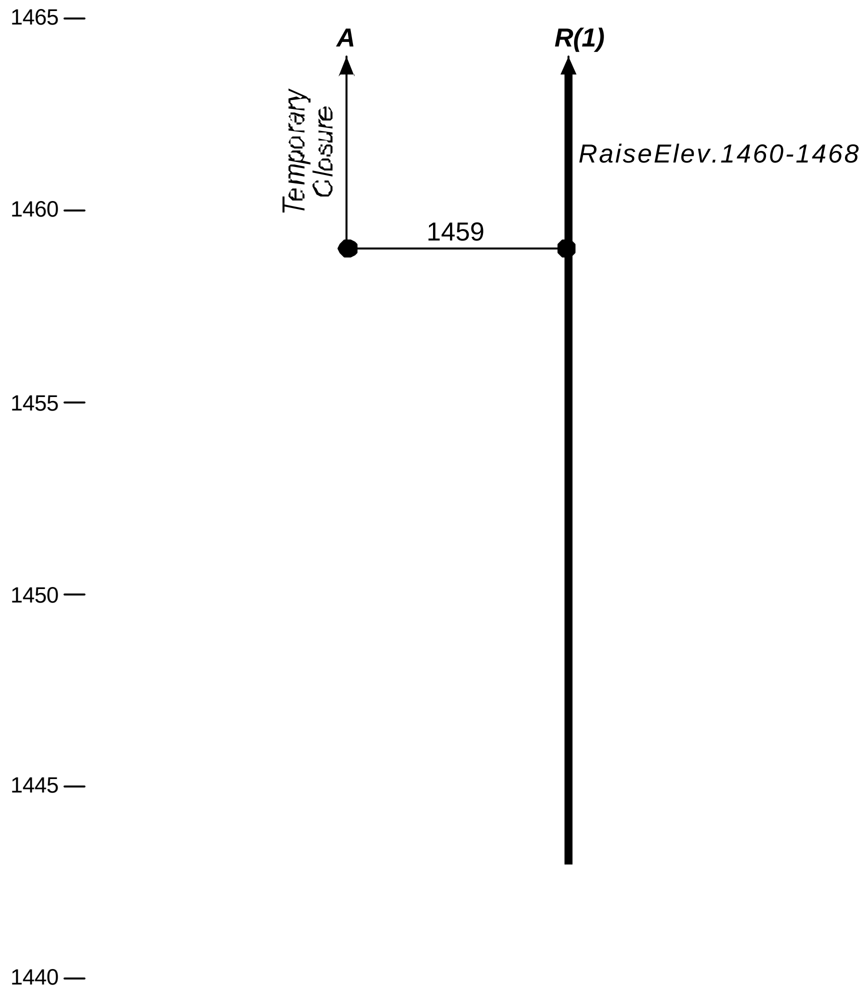
Stochastic Analysis Results: The flood protection strategy that was analyzed for protecting ND Highway 20 (North of City of Devils Lake) was one road raise. This strategy is highlighted on the decision tree (Figure 2.20-2). The average annual net benefits for this strategy were less than zero (-$26,600). The BCR for this strategy was less than one (0.66). These results indicate that this strategy was not economically justified. The present worth annualized detour damages that would be prevented by this strategy were computed to be $41,900. The stochastic results are averages over 10,000 traces.

Results for Specific Scenarios: In the economic analysis, flood protection strategies were also analyzed for three specific climate futures. For ND Highway 20 (North of City of Devils Lake), the identified strategy and the economic indices for each of the three climate futures are as follows:

- Wet Future – For the wet future, the annual net benefits were -$40,300, and the BCR was 0.96, indicating that this strategy was not economically justified. For this future, the present worth annualized detour damages that would be prevented were computed at $829,100.
- First Moderate Future – For the first moderate future, lake levels do not reach the first damage levels.
- Second Moderate Future – For the second moderate future, lake levels do not reach the first damage levels.

Figure 2.20-1
LOCATION MAP
FEATURE 20: ND HIGHWAY 20
(NORTH OF THE CITY OF
DEVILS LAKE)
Devils Lake Infrastructure
Protection Study

DATA: 1997 USGS Digital Ortho Quad



Lowest Road Elevation: 1460

Flood Protection Strategy

Decision required at this point

Trigger point for action, no decision needed

R(1) Incremental road raise (number of times)

R Road raise to 1468

A Temporary closure of road

Figure 2.20-2

DECISION TREE
FEATURE 20: ND HIGHWAY 20
(North of City of Devils Lake)
Devils Lake Infrastructure Protection Study

Table 2.20-1

Flood Damages
Feature 20: ND Highway 20 (North of City of Devils Lake)
Devils Lake Infrastructure Protection Study

DAMAGES

Action Level	Annual Detour Damages
	(THOUSANDS)
AL1	$3,375

DAMAGE BREAKDOWN

Damage	AL1				
	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Annual Detour Damages	ND HWY 20				
	HR/YEAR	137,190	HR	$7.00	$960
	MILES/YEAR	7,545,456	MILE	$0.32	$2,415
	Total				$3,375

Restoration Damages		Excavation				Fabric Liner				Aggregate Base Course				Fill				Bituminous Pavement				Bridge Repair			
Elevation	Total (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Cost (THOUSANDS)
1459	$0																								
1460	$4,848	105,600	CY	$2.65	$280	187,028	SY	$1.33	$249	22,733	CY	$21.20	$482	156,352	CY	$4.77	$746	42,592	TON	$47.70	$2,032	2	EA	$530,000	$1,060
1461	$4,848	105,600	CY	$2.65	$280	187,028	SY	$1.33	$249	22,733	CY	$21.20	$482	156,352	CY	$4.77	$746	42,592	TON	$47.70	$2,032	2	EA	$530,000	$1,060
1462	$4,848	105,600	CY	$2.65	$280	187,028	SY	$1.33	$249	22,733	CY	$21.20	$482	156,352	CY	$4.77	$746	42,592	TON	$47.70	$2,032	2	EA	$530,000	$1,060
1463	$4,848	105,600	CY	$2.65	$280	187,028	SY	$1.33	$249	22,733	CY	$21.20	$482	156,352	CY	$4.77	$746	42,592	TON	$47.70	$2,032	2	EA	$530,000	$1,060

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.

Table 2.20-2

Flood Protection Costs
Feature 20: ND Highway 20 (North of City of Devils Lake)
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Action Level	Lake Elevation	A Temporary Closure at AL1	R(1) Raise at AL1
	(MSL)	(THOUSANDS)	
AL1	1459	$0	$33,382

COST BREAKDOWN

Strategy		R(1) Lake Elevation 1454 Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Incremental Raise						
	Road Raise	ND Highway 20				
		Fabric Liner	648,663	SY	$1.33	$863
		Aggregate Base	50,099	CY	$21.20	$1,062
		Fill	1,433,069	CY	$9.00	$12,898
		Riprap	434,074	CY	$30.00	$13,022
		Bituminous	93,864	TON	$47.70	$4,477
		Bridge Rebuild	2	EA	$530,000	$1,060
		Total				**$33,382**

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.

Table 2.20 - 3

Economic Analysis of Strategies for Highway 20 North of the City of Devils Lake (Feature 20)

Stochastic Analysis (ST) — Mean Value over 10,000 Traces (Annual)

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Level	$0	$0	$0	$9,200	$41,900	$0	$51,100	$0	$0	--
R(1)	Road Raise to 1468	$77,700	$0	$77,700	$0	$0	$0	$0	$51,100	-$26,600	0.66

Wet Future Scenario (WF) — (Annual)

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Level	$0	$0	$0	$69,100	$829,100	$0	$898,200	$0	$0	--
R(1)	Road Raise to 1468	$938,600	$0	$938,600	$0	$0	$0	$0	$898,200	-$40,300	0.96

Moderate Future 1 Scenario (M1) — (Annual)

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Level	$0	$0	$0	$0	$0	$0	$0	$0	$0	--
R(1)	Road Raise to 1468	$0	$0	$0	$0	$0	$0	$0	$0	$0	--

Moderate Future 2 Scenario (M2) — (Annual)

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Level	$0	$0	$0	$0	$0	$0	$0	$0	$0	--
R(1)	Road Raise to 1468	$0	$0	$0	$0	$0	$0	$0	$0	$0	--

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.375% and rounded to the nearest $100.
* Total benefits are calculated as the total damages incurred for "temporary closure strategy" minus the total damages for the strategy implemented (G(S)).
The "No Protection" strategy for roads has been defined as temporary closure during floods at the first action level with restoration when the lake recedes.

Attachment to 2.20:
ND Highway 20 (north of the City of Devils Lake) Economic Analysis Assumptions

No feature-specific assumptions were made for Feature 20.

A. General Assumptions

1. Decisions were assumed to occur when the lake level is within (or predicted by the National Weather Service to be within) 1 foot of the lowest road elevation. This assumption is consistent with current practices in the area as dictated by funding agencies. In the past, funding for road raises has not been

   water during that year.

2. If the road includes a bridge having a low chord elevation below the lowest road elevation, it was assumed that no decision would occur until the lake level was within 1 foot of the lowest road elevation. This assumption follows current practices in the area.

B. Road Raises

1. Road raise costs were calculated in the manner presented in a previous study (*Devils Lake Flood Control: Economics Database Update: Transportation Report*, Barr Engineering Company, January 1998). Unit costs for construction materials were updated for inflation by multiplying them by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001. Additionally the cost of riprap and fill were increased from $20 to $30 and $4.50 to $9.00, respectively. Based on conversations with the NDDOT, railroad companies, and the Corps of Engineers the new costs for riprap and fill are more representative of the costs in the area.

2. The last road raise was assumed to be to elevation 1468. At this elevation, roads would be 5 feet above the assumed maximum lake level (elevation 1463).

3. The final incremental road raise (to elevation 1468) was assumed to be no more than 8 feet and no less than 4 feet.

C. Temporary Road Closure During Floods

1. It was assumed that if a road was temporarily closed, it would be restored after the lake level has receded 1 foot below the top of road. All of the road features in this study are highly traveled. It is very likely that people would want to use these roads again if the lake level receded after flooding, assuming that communities, businesses, farmsteads, and residents continue to generate the same level of traffic as at present.

2. Restoration damages were calculated in the manner presented in *Devils Lake Flood Control: Economics Database Update: Transportation Report,* Barr Engineering Company, January 1998. Unit costs for construction materials were updated for inflation by multiplying them by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001.

3. Detour damages were included for every year that a road is temporarily closed, as well as for the first year that the lake has receded. It was assumed that during the first year after the lake has receded, the road would be under restoration. During this first year, there would be both a detour damage and restoration damage. After this first year, there would be no further detour or restoration damages unless the lake rises to within 1 foot of the road again.

4. Restoration of a road would only occur after the lake has receded to 1 foot below the lowest elevation in that road. This was based on the assumption that restoration would only occur when there is no water on any part of the road and there would be only minor potential for wave action damage on the road.

5. Detour damages were calculated using a cost of $7 per hour of additional travel time, 1.5 people per vehicle, and $0.32 per mile for additional travel distance (Corps of Engineers, March, 2001). Additional time and miles traveled were taken from the results of the QRS II model used in *Devils Lake Flood Control: Economics Database Update: Transportation Report,* Barr Engineering Company, January 1998. The QRS II model determines the overall effect of a closed road on an entire network of traffic, incorporating the fact that traffic consists of trips having different origins and destinations.

6. Two features can have mutually interdependent detour routes if they are the most reasonable detours. In these cases, it was assumed that either the analyzed feature or the other feature would be raised or rerouted. In these cases, the interdependency was noted.

D. Road Reroutes

1. There was no logical reroute for this feature.

2.21 Summary of Economic Analysis Investigation for Feature 21: ND Highway 20 (City of Devils Lake Levee to ND Highway 57)

2.21.0 Flood Protection Strategy

The flood protection strategy that was analyzed in the Economic Analysis of Devils Lake Alternatives for ND Highway 20 (City of Devils Lake Levee to ND Highway 57) was incremental road raises.

2.21.1 General Information

Feature Type: Road

Location: ND Highway 20 (City of Devils Lake Levee to ND Highway 57) is located in Creel Township in Ramsey County. The feature extends approximately 3 miles between ND Highway 57 at the southeast to the levee on the south side of Devils Lake. The accompanying Figure 2.21-1 shows the feature's location and extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: ND Highway 20 (City of Devils Lake Levee to ND Highway 57) is a two-lane bituminous-surfaced state highway. The centerline elevation is at a minimum of 1455. Portions of this roadway are currently acting as a dam (see analysis of Feature 25).

Significance: ND Highway 20 (City of Devils Lake Levee to ND Highway 57) is important because it is the major north-south arterial route through the Devils Lake region. It provides primary access to and from the City of Devils Lake from the south side of the lake, particularly the Spirit Lake Nation Reservation.

Damages: The flooding of ND Highway 20 (City of Devils Lake Levee to ND Highway 57) would result in the following damages:

- Detour damages resulting from the added travel time and miles traveled when ND Highway 20 (City of Devils Lake Levee to ND Highway 57) is closed and traffic is detoured
- Restoration damages resulting from repairs that would be necessary to bring the highway back to a useable condition after a period of inundation

Owner/Sponsor: The North Dakota Department of Transportation is responsible for managing and maintaining ND Highway 20 (City of Devils Lake Levee to ND Highway 57).

Lead Federal Agency: The Federal Highway Administration would take the lead for ND Highway 20 (City of Devils Lake Levee to ND Highway 57) in any flood protection work that may take place.

2.21.2 Feature Protection

History of Flood Protection: In the past, flood protection for ND Highway 20 (City of Devils Lake Levee to ND Highway 57) has consisted of raising the road to keep it from being overtopped.

General Protection Strategy: The analysis identified and evaluated one approach for protecting ND Highway 20 (City of Devils Lake Levee to ND Highway 57): incremental road raises.

Protection Strategy by Lake Level: The Economic Analysis of Devils Lake Alternatives evaluated this protection strategy, with flood protection decisions being made at various lake levels as Devils Lake continued to rise. Figure 2.21-2 shows the decision tree for ND Highway 20 (City of Devils Lake Levee to ND Highway 57). As shown on Figure 2.21-2, the stepwise approach to flood protection for ND Highway 20 (City of Devils Lake Levee to ND Highway 57) that was analyzed consisted of the following:

1. At lake elevation 1454, a decision would be made as to whether the road would be raised to 1460, or temporarily closed.
2. If the road were raised at the first action level, at lake elevation 1459 another decision would be made as to whether the road would be raised to 1468, or temporarily closed.

The maximum protection strategy that was analyzed at the first action level was raising the road to 1468. (Note that for the analysis, the decision regarding whether or not to raise the road is made at a time when the lake is one foot below the minimum highway elevation that resulted from the most recent raise.)

Interdependencies: The protection of ND Highway 20 (City of Devils Lake Levee to ND Highway 57) is related to the protection of several other features:

- Feature 2: City of Devils Lake – ND Highway 20 is the main transportation route to the City of Devils Lake from the south. If ND Highway 20 (City of Devils Lake Levee to ND Highway 57) were temporarily closed, traffic into and out of the City of Devils Lake would be detoured.
- Feature 3: Fort Totten – ND Highway 20 (City of Devils Lake Levee to ND Highway 57) is one segment of the primary route between the City of Devils Lake and Fort Totten. Therefore, If ND Highway 20 (City of Devils Lake Levee to ND Highway 57) were temporarily closed, traffic between Fort Totten and the City of Devils Lake would be detoured.
- Feature 5: St. Michael – ND Highway 20 (City of Devils Lake Levee to ND Highway 57) is one segment of the primary route between the City of Devils Lake and St. Michael.

Therefore, if ND Highway 20 (City of Devils Lake Levee to ND Highway 57) were temporarily closed, traffic between St. Michael and the City of Devils Lake would be detoured.

- Feature 6: Gilbert C. Grafton Military Reservation – The protection of Camp Grafton is directly related to the protection of ND Highway 20 because the primary access to Camp Grafton is from ND Highway 20. Temporary closure of ND Highway 20 would impact access to the Camp.
- Feature 13: US Highway 2 – ND Highway 20 (City of Devils Lake Levee to ND Highway 57) intersects US Highway 2 in the City of Devils Lake. If US Highway 2 is closed, ND Highway 20 (City of Devils Lake Levee to ND Highway 57) would experience changes in traffic as a detour routes are implemented (and vice versa).
- Feature 15: ND Highway 57 (between BIA Highway 1 and US Highway 281) – If ND Highway 20 (City of Devils Lake Levee to ND Highway 57) is temporarily closed, ND Highway 57 (BIA Highway 1 to US Highway 281) would experience changes in traffic as a detour routes are implemented.
- Feature 16: US Highway 281 (South of US Highway 2) – If ND Highway 20 (City of Devils Lake Levee to ND Highway 57) is closed, US Highway 281 (South of US Highway 2) would experience increased traffic as a detour route.
- Feature 18: ND Highway 19 – If ND Highway 20 (City of Devils Lake Levee to ND Highway 57) is closed, ND Highway 19 would experience increased traffic as a detour route.
- Feature 24: BIA Highway 6 – Temporary closure of ND Highway 20 (City of Devils Lake Levee to ND Highway 57) will increase the amount of traffic on BIA Highway 6 as a detour route.

Table 2.0-1, mentioned earlier in this report, provides a summary of the interdependencies among the features.

2.21.3 Feature Economics

Damages: For ND Highway 20 (City of Devils Lake Levee to ND Highway 57), the damages resulting from flooding were estimated up to the maximum lake level (1463). The damage computations for ND Highway 20 (City of Devils Lake Levee to ND Highway 57) are summarized in the accompanying Table 2.21-1.

The detour damages for ND Highway 20 (City of Devils Lake Levee to ND Highway 57), assume that all other features are open, and traffic is routed around the lake if ND Highway 20 (City of

Devils Lake Levee to ND Highway 57) is temporarily closed. This was one of the four features in the Economics Analysis that was credited with the large detour damages around the lake (See discussion in Section 2.0.1.5). The computation of basin-wide damages required certain assumptions regarding interdependent roads in order to ensure that the basin-wide Economic Analysis was accurately representing overall traffic patterns.

The top portion of Table 2.21-1 gives a summary of the annual detour damages that would occur during the years when the highway was flooded. It also shows road restoration damages that can be expected when the lake recedes. Restoration damages include rebuilding the road with excavation, fill, surface material, and bridge repairs. Restoration damages are a per-event damage.

The lower portion of the table shows the breakdown of these summary values for each of the three action levels. It gives quantities in terms of miles per year (of extra miles traveled as a result of detours) and hours per year (of additional travel time resulting from detours) for the detour damages. Also shown are quantities and line-item damages for excavation, fabric liner, aggregate base course, and fill for road restoration work when waters recede.

Unit prices for all the damage computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for ND Highway 20 (City of Devils Lake Levee to ND Highway 57) are listed in the Feature 21 Assumptions listing, appended to this Section 2.21.

Costs: The costs of providing flood protection for ND Highway 20 (City of Devils Lake Levee to ND Highway 57) are detailed in the accompanying Table 2.21-2. Quantities and line-item totals are listed.

The top portion of the table gives the costs of providing flood protection (as represented in the analysis) by action level for all of the flood protection strategies. The lower portion of the table gives a breakdown of the quantities and costs by line item: fabric liner, aggregate base, fill, riprap, and bituminous pavement material.

Unit costs for all the cost computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for ND Highway 20 (City of Devils Lake Levee to ND Highway 57) are listed in the Feature 21 Assumptions listing, appended to this Section 2.21.

2.21.4 Results of Economic Analysis

The results of the Economic Analysis for the ND Highway 20 (City of Devils Lake Levee to ND Highway 57) are listed in Table 2.21-3.

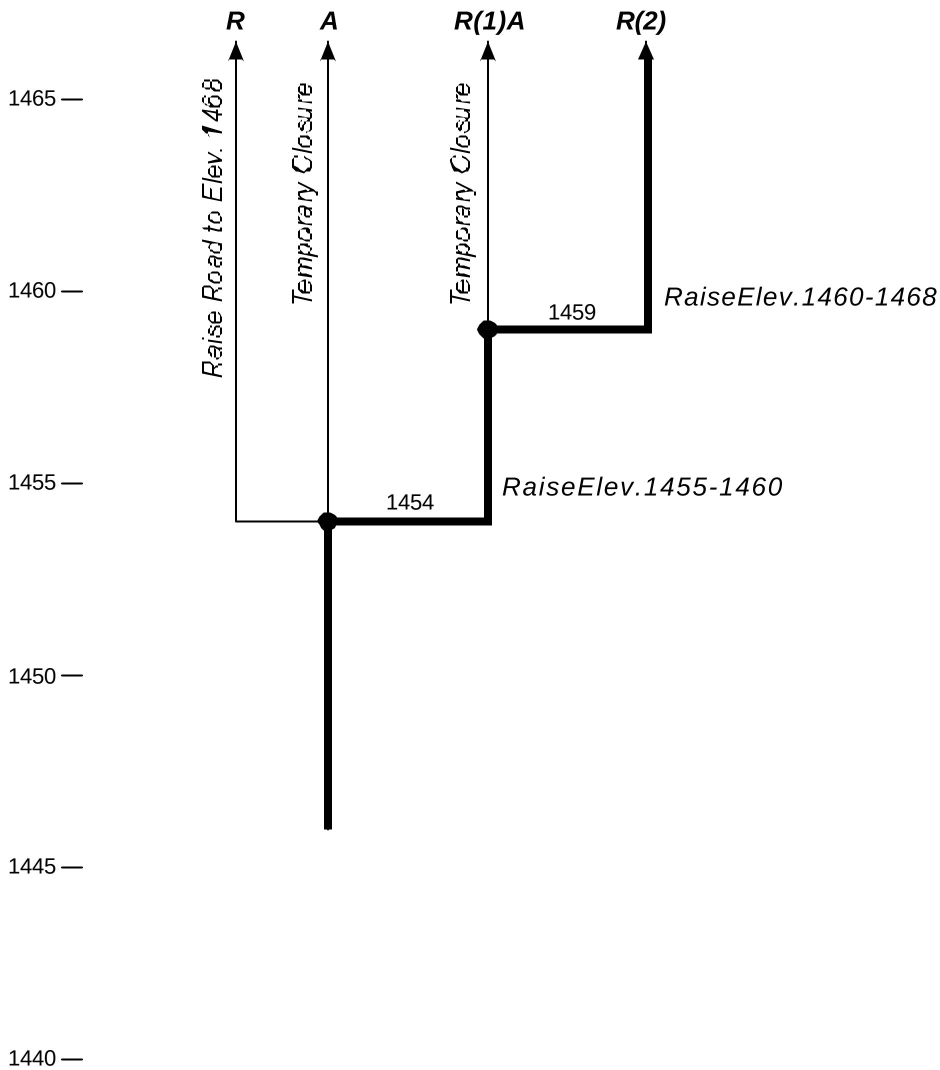
Stochastic Analysis Results: The flood protection strategy that was analyzed for protecting ND Highway 20 (City of Devils Lake Levee to ND Highway 57) was two incremental road raises. This strategy is highlighted on the decision tree (Figure 2.21-2). The average annual net benefits for this strategy were greater than zero ($602,100). The BCR for this strategy was greater than one (6.64). These results indicate that this strategy was economically justified. The present worth annualized detour damages that would be prevented by this strategy were computed to be $694,900. The stochastic results are averages over 10,000 traces.

Results for Specific Scenarios: In the economic analysis, flood protection strategies were also analyzed for three specific climate futures. For ND Highway 20 (City of Devils Lake Levee to ND Highway 57), the identified strategy and the economic indices for each of the three climate futures are as follows:

- Wet Future – For the wet future, the annual net benefits were $6,820,000, and the BCR was 9.16, indicating that this strategy was economically justified. For this future, the present worth annualized detour damages that would be prevented were computed at $7,616,700.
- First Moderate Future – For the first moderate future, lake levels do not reach first damage levels.
- Second Moderate Future – For the second moderate future, the annual net benefits were $1,484,200, and the BCR was 5.59, indicating that this strategy was economically justified. For this future, the present worth annualized detour damages that would be prevented were computed at $1,738,400.

Figure 2.21-1
LOCATION MAP
FEATURE 21: ND HIGHWAY 20
(CITY OF DEVILS LAKE
TO ND HIGHWAY 57)
Devils Lake Infrastructure
Protection Study

DATA: 1997 USGS Digital Ortho Quad



Lowest Road Elevation: 1455

Flood Protection Strategy

Decision required at this point

Trigger point for action, no decision needed

R(1) Incremental road raise (number of times)

R Road raise to 1468

A Temporary closure of road

Figure 2.21-2

DECISION TREE
FEATURE 21: ND HIGHWAY 20
(City of Devils Lake Levee to ND Highway 57)
Devils Lake Infrastructure Protection Study

P:\34\36\120\DECISION TREES\2002 FIGURES\FIGURE2_21.CDR RLG 01-02-03

Table 2.21-1

Flood Damages
Feature 21: ND Highway 20 (City of Devils Lake Levee to ND Highway 57)
Devils Lake Infrastructure Protection Study

DAMAGES

Action Levels	Annual Detour Damages
	(THOUSANDS)
AL1 - AL2	$13,104

DAMAGE BREAKDOWN

	AL1 - AL2				
Damage	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Annual Detour Damages	ND HWY 20				
	HR/YEAR	532,687	HR	$7.00	$3,729
	MILES/YEAR	29,297,805	MILE	$0.32	$9,375
	Total				$13,104

Restoration Damages

		Excavation				Fabric Liner				Aggregate Base Course				Fill				Bituminous Pavement				Bridge Repair			
Elevation	Total (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Cost (THOUSANDS)
1454	$0																								
1455	$2,949	82,200	CY	$2.65	$218	145,584	SY	$1.33	$194	17,696	CY	$21.20	$375	121,706	CY	$4.77	$581	33,154	TON	$47.70	$1,581	0	EA	$530,000	$0
1456	$2,949	82,200	CY	$2.65	$218	145,584	SY	$1.33	$194	17,696	CY	$21.20	$375	121,706	CY	$4.77	$581	33,154	TON	$47.70	$1,581	0	EA	$530,000	$0
1457	$2,949	82,200	CY	$2.65	$218	145,584	SY	$1.33	$194	17,696	CY	$21.20	$375	121,706	CY	$4.77	$581	33,154	TON	$47.70	$1,581	0	EA	$530,000	$0
1458	$2,949	82,200	CY	$2.65	$218	145,584	SY	$1.33	$194	17,696	CY	$21.20	$375	121,706	CY	$4.77	$581	33,154	TON	$47.70	$1,581	0	EA	$530,000	$0
1459	$2,949	82,200	CY	$2.65	$218	145,584	SY	$1.33	$194	17,696	CY	$21.20	$375	121,706	CY	$4.77	$581	33,154	TON	$47.70	$1,581	0	EA	$530,000	$0
1460	$2,949	82,200	CY	$2.65	$218	145,584	SY	$1.33	$194	17,696	CY	$21.20	$375	121,706	CY	$4.77	$581	33,154	TON	$47.70	$1,581	0	EA	$530,000	$0
1461	$2,949	82,200	CY	$2.65	$218	145,584	SY	$1.33	$194	17,696	CY	$21.20	$375	121,706	CY	$4.77	$581	33,154	TON	$47.70	$1,581	0	EA	$530,000	$0
1462	$2,949	82,200	CY	$2.65	$218	145,584	SY	$1.33	$194	17,696	CY	$21.20	$375	121,706	CY	$4.77	$581	33,154	TON	$47.70	$1,581	0	EA	$530,000	$0
1463	$2,949	82,200	CY	$2.65	$218	145,584	SY	$1.33	$194	17,696	CY	$21.20	$375	121,706	CY	$4.77	$581	33,154	TON	$47.70	$1,581	0	EA	$530,000	$0

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.

Table 2.21-2

Flood Protection Costs
Feature 21: ND Highway 20 (City of Devils Lake Levee to ND Highway 57)
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Action Level	Lake Elevation	R Maximum Raise at AL1	A Temporary Closure at AL1	R(1)A Raise at AL1; Temporary Closure at AL2	R(2) Raise at AL1, AL2
	(MSL)	(THOUSANDS)			
AL1	1454	$24,859	$0	$10,803	$10,803
AL2	1459	$0	$0	$0	$14,056

COST BREAKDOWN

		R									
		R(1)A									
		R(2)					R(2)				
		Lake Elevation 1454					Lake Elevation 1459				
Strategy		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Incremental Raise											
	Road Raise	ND Highway 20					ND Highway 20				
		Fabric Liner	222,881	SY	$1.33	$296	Fabric Liner	185,583	SY	$1.33	$247
		Aggregate Base	17,696	CY	$21.20	$375	Aggregate Base	0	CY	$21.20	$0
		Fill	452,861	CY	$9.00	$4,076	Fill	1,120,356	CY	$9.00	$10,083
		Riprap	149,148	CY	$30.00	$4,474	Riprap	124,189	CY	$30.00	$3,726
		Bituminous	33,154	TON	$47.70	$1,581	Bituminous	0	TON	$47.70	$0
		Bridge Rebuild	0	EA	$530,000	$0	Bridge Rebuild	0	EA	$530,000	$0
		Total				**$10,803**	**Total**				**$14,056**

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. The costs for the Maximum Raise at AL1 strategy (R) is equal to the sum of the costs for all incremental raises.

Table 2.21 - 3

Economic Analysis of Strategies for
Highway 20 from the City of Devils Lake Levee to Highway 57
(Feature 21)

Strategy		Stochastic Analysis (ST) Mean Value over 10,000 Traces (Annual)									
		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Le	$0	$0	$0	$14,100	$694,900	$0	$709,000	$0	$0	--
R	Road Raise to 1468	$170,500	$0	$170,500	$0	$0	$0	$0	$709,000	$538,500	4.16
R(1)A	1 Road Raise: Then Temporary Closure During Flo	$74,100	$0	$74,100	$5,700	$162,800	$0	$168,500	$540,500	$466,300	7.29
R(2)	2 Incr. Road Raises	$106,800	$0	$106,800	$0	$0	$0	$0	$709,000	$602,100	6.64

Strategy		Wet Future Scenario (WF) (Annual)									
		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Le	$0	$0	$0	$38,500	########	$0	$7,655,300	$0	$0	--
R	Road Raise to 1468	########	$0	$1,012,700	$0	$0	$0	$0	$7,655,300	$6,642,600	7.56
R(1)A	1 Road Raise: Then Temporary Closure During Flo	$440,100	$0	$440,100	$42,000	########	$0	$3,261,300	$4,394,000	$3,953,900	9.98
R(2)	2 Incr. Road Raises	$835,300	$0	$835,300	$0	$0	$0	$0	$7,655,300	$6,820,000	9.16

Strategy		Moderate Future 1 Scenario (M1) (Annual)									
		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Le	$0	$0	$0	$0	$0	$0	$0	$0	$0	--
R	Road Raise to 1468	$0	$0	$0	$0	$0	$0	$0	$0	$0	--
R(1)A	1 Road Raise: Then Temporary Closure During Flo	$0	$0	$0	$0	$0	$0	$0	$0	$0	--
R(2)	2 Incr. Road Raises	$0	$0	$0	$0	$0	$0	$0	$0	$0	--

Strategy		Moderate Future 2 Scenario (M2) (Annual)									
		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Le	$0	$0	$0	$68,900	########	$0	$1,807,200	$0	$0	--
R	Road Raise to 1468	$743,500	$0	$743,500	$0	$0	$0	$0	$1,807,200	$1,063,700	2.43
R(1)A	1 Road Raise: Then Temporary Closure During Flo	$323,100	$0	$323,100	$0	$0	$0	$0	$1,807,200	$1,484,200	5.59
R(2)	2 Incr. Road Raises	$323,100	$0	$323,100	$0	$0	$0	$0	$1,807,200	$1,484,200	5.59

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.375% and rounded to the nearest $100.
* Total benefits are calculated as the total damages incurred for "temporary closure strategy" minus the total damages for the strategy implemented (G(S)).
The "No Protection" strategy for roads has been defined as temporary closure during floods at the first action level with restoration when the lake recedes.

Attachment to 2.21:
ND Highway 20 (City of Devils Lake Levee to ND Highway 57) Economic Analysis Assumptions

No feature-specific assumptions were made for Feature 21.

A. General Assumptions

1. Decisions were assumed to occur when the lake level is within (or predicted by the National Weather Service to be within) 1 foot of the lowest road elevation. This assumption is consistent with current practices in the area as dictated by funding agencies. In the past, funding for road raises has not been

   water during that year.

2. If the road includes a bridge having a low chord elevation below the lowest road elevation, it was assumed that no decision would occur until the lake level was within 1 foot of the lowest road elevation. This assumption follows current practices in the area.

B. Road Raises

1. Road raise costs were calculated in the manner presented in a previous study (*Devils Lake Flood Control: Economics Database Update: Transportation Report*, Barr Engineering Company, January 1998). Unit costs for construction materials were updated for inflation by multiplying them by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001. Additionally the cost of riprap and fill were increased from $20 to $30 and $4.50 to $9.00, respectively. Based on conversations with the NDDOT, railroad companies, and the Corps of Engineers the new costs for riprap and fill are more representative of the costs in the area.

2. The last road raise was assumed to be to elevation 1468. At this elevation, roads would be 5 feet above the assumed maximum lake level (elevation 1463).

3. The final incremental road raise (to elevation 1468) was assumed to be no more than 8 feet and no less than 4 feet.

C. Temporary Road Closure During Floods

1. It was assumed that if a road was temporarily closed, it would be restored after the lake level has receded 1 foot below the top of road. All of the road features in this study are highly traveled. It is very likely that people would want to use these roads again if the lake level receded after flooding, assuming that communities, businesses, farmsteads, and residents continue to generate the same level of traffic as at present.

2. Restoration damages were calculated in the manner presented in *Devils Lake Flood Control: Economics Database Update: Transportation Report,* Barr Engineering Company, January 1998. Unit costs for construction materials were updated for inflation by multiplying them by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001.

3. Detour damages were included for every year that a road is temporarily closed, as well as for the first year that the lake has receded. It was assumed that during the first year after the lake has receded, the road would be under restoration. During this first year, there would be both a detour damage and restoration damage. After this first year, there would be no further detour or restoration damages unless the lake rises to within 1 foot of the road again.

4. Restoration of a road would only occur after the lake has receded to 1 foot below the lowest elevation in that road. This was based on the assumption that restoration would only occur when there is no water on any part of the road and there would be only minor potential for wave action damage on the road.

5. Detour damages were calculated using a cost of $7 per hour of additional travel time, 1.5 people per vehicle, and $0.32 per mile for additional travel distance (Corps of Engineers, March, 2001). Additional time and miles traveled were taken from the results of the QRS II model used in *Devils Lake Flood Control: Economics Database Update: Transportation Report,* Barr Engineering Company, January 1998. The QRS II model determines the overall effect of a closed road on an entire network of traffic, incorporating the fact that traffic consists of trips having different origins and destinations.

6. There is more commitment on the part of the North Dakota Department of Transportation (NDDOT) to the Highway 57 causeway than to the Highway 20 causeway through The Narrows. Therefore, Highway 57 was assumed to be the detour route for the Highway 20 causeway. If the Highway 57 causeway was temporarily closed during flooding, it was assumed that the Highway 20 causeway would also be temporarily closed.

7. The detour route for Highway 57 is around the lake to the west via Highway 281 and Highway 19. Woods-Rutten Road was considered as a detour route for Highway 57, but it was not retained as a viable alternative, because it would have to be significantly raised and improved to carry the traffic of Highway 57.

8. Detour paths were determined assuming that all other featured roads would be open (with three exceptions: the Highway 57 detour assumes that Highway 20 across The Narrows is closed and both the BIA 1 and the BIA 6 detours assume that Highway 20 from Highway 57 to Tokio is closed). No

effort was made to link detour routes with lake level. However, if a featured road was presented as a detour route, an "interdependency" was noted.

9. The analysis of Features 23 (BIA 1 between Highway 57 and BIA 6) and Feature 24 (BIA 6 between Highway 20 and Fort Totten) assumed that Feature 22 (Highway 20 between Highway 57 and Tokio) is temporarily closed during high lake levels. BIA 1 and BIA 6 are part of the north-south detour for Highway 20 and the preliminary analysis indicated that Feature 22 would likely be temporarily closed during high lake levels.

10. Two features can have mutually interdependent detour routes if they are the most reasonable detours. In these cases, it was assumed that either the analyzed feature or the other feature would be raised or rerouted. In these cases, the interdependency was noted.

D. Road Reroutes

1. There were no logical reroutes for this feature.

2.22 Summary of Economic Analysis Investigation for Feature 22: ND Highway 20 (ND Highway 57 to Tokio)

2.22.0 Flood Protection Strategy

The flood protection strategy that was analyzed in the Economic Analysis of Devils Lake Alternatives for ND Highway 20 (ND Highway 57 to Tokio) was incremental road raises.

2.22.1 General Information

Feature Type: Road

Location: ND Highway 20 (ND Highway 57 to Tokio) is located primarily in Mission Township, Benson County, on the Spirit Lake Nation Reservation. The northern portion of the feature is located in Creel South Township, Ramsey County. The feature extends 10.6 miles between ND Highway 57 at the northwest to the town of Tokio to the south. The accompanying Figure 2.22-1 shows the feature's location and extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: ND Highway 20 (ND Highway 57 to Tokio) is a two-lane bituminous-surfaced state highway. The centerline elevation varies from 1447.5 to 1495 near Tokio. Portions of this roadway are acting as dams (see analysis of Feature 25).

Significance: ND Highway 20 (ND Highway 57 to Tokio) is important because it is the major north/south arterial route through the Devils Lake region and it provides primary access across Devils Lake from the north to Mission Township and the eastern portion of the Spirit Lake Nation Reservation.

Damages: The flooding of ND Highway 20 (ND Highway 57 to Tokio) would result in the following damages:

- Detour damages resulting from the added travel time and miles traveled when ND Highway 20 (ND Highway 57 to Tokio) is closed and traffic is detoured
- Restoration damages resulting from repairs that would be necessary to bring the highway back to a useable condition after a period of inundation

Owner/Sponsor: The North Dakota Department of Transportation is responsible for managing and maintaining ND Highway 20 (ND Highway 57 to Tokio).

Lead Federal Agency: The Federal Highway Administration would take the lead for ND Highway 20 (ND Highway 57 to Tokio) in any flood protection work that may take place.

2.22.2 Feature Protection

History of Flood Protection: In the past, flood protection for ND Highway 20 (ND Highway 57 to Tokio) has consisted of raising the road to keep it from being overtopped. The most recent raise of ND Highway 20 occurred in 1999 when the road elevation was raised from 1448.5 to 1452.5 for 3.7 miles. The two raise locations were on the north and east side of Sections 3 and 4 and in Sections 26 and 35 in Mission Township.

In 1997, the Corps of Engineers constructed three emergency levees north and northeast of the east-west portion of ND Highway 20. These levees protect the 2,000-foot section of ND Highway 20 immediately west of the road's intersection with BIA Highway 9 that has a surface elevation at about 1445. The western-most of the three levees, constructed along a township road in Section 35 (T153N64W), was raised to 1447.6 in 1998. The other two levee sections, located in Section 35 (T153N64W) and Section 31 (T153N63W), were also raised in 1998 to 1449.

General Protection Strategy: The analysis identified and evaluated one approach for protecting ND Highway 20 (ND Highway 57 to Tokio): incremental road raises.

Protection Strategy by Lake Level: The Economic Analysis of Devils Lake Alternatives evaluated this protection strategy, with flood protection decisions being made at various lake levels as Devils Lake continued to rise. Figure 2.22-2 shows the decision tree for ND Highway 20 (ND Highway 57 to Tokio). As shown on Figure 2.22-2, the stepwise approach to flood protection for ND Highway 20 (ND Highway 57 to Tokio) that was analyzed consisted of the following:

1. At lake elevation 1446.5, a decision would be made as to whether the road would be raised to 1452.5, or temporarily closed.

2. If the road were raised at the first action level, at lake elevation 1451.5 another decision would be made as to whether the road would be raised to 1457.5, or temporarily closed.

3. If the road were raised at the second action level, at lake elevation 1456.5 another decision would be made as to whether the road would be raised to 1462.5, or temporarily closed.

4. If the road were raised at the third action level, at lake elevation 1461.5 another decision would be made as to whether the road would be raised to 1468, or temporarily closed.

The maximum protection strategy that was analyzed at the first action level was raising the road to 1468. (Note that for the analysis, the decision regarding whether or not to raise the road is made at a time when the lake is one foot below the minimum highway elevation that resulted from the most recent raise.)

Interdependencies: The protection of ND Highway 20 (ND Highway 57 to Tokio) is related to the protection of several other features:

- Feature 2: City of Devils Lake – ND Highway 20 is the main transportation route to the City of Devils Lake from the south. If ND Highway 20 (ND Highway 57 to Tokio) were temporarily closed, traffic into and out of the City of Devils Lake would be detoured.
- Feature 3: Fort Totten – ND Highway 20 (ND Highway 57 to Tokio) is one segment of a route between the City of Devils Lake and Fort Totten. Therefore, If ND Highway 20 (City of Devils Lake Levee to ND Highway 57) were temporarily closed, traffic between Fort Totten and the City of Devils Lake would be detoured.
- Feature 5: St. Michael – ND Highway 20 (ND Highway 57 to Tokio) is one segment of a route between the City of Devils Lake and St. Michael. Therefore, if ND Highway 20 (ND Highway 57 to Tokio) were temporarily closed, traffic between St. Michael and the City of Devils Lake would be detoured.
- Feature 15: ND Highway 57 (between BIA Highway 1 and US Highway 281) – If ND Highway 20 (ND Highway 57 to Tokio) is temporarily closed, traffic on ND Highway 57 would increase as a detour route.
- Feature 23: BIA Highway 1 – If ND Highway 20 (ND Highway 57 to Tokio) is temporarily closed, BIA Highway 1 becomes critical for carrying north-south traffic in the Devils Lake area.
- Feature 24: BIA Highway 6 – BIA Highway 6 shares a major intersection with ND Highway 20 (ND Highway 57 to Tokio), so traffic on BIA 6 will be impacted by decisions regarding ND Highway 20 (ND Highway 57 to Tokio).

Table 2.0-1, mentioned earlier in this report, provides a summary of the interdependencies among the features.

2.22.3 Feature Economics

Damages: For ND Highway 20 (ND Highway 57 to Tokio), the damages resulting from flooding were estimated up to the maximum lake level (1463). The damage computations for ND Highway 20 (ND Highway 57 to Tokio) are summarized in the accompanying Table 2.22-1.

The top portion of Table 2.22-1 gives a summary of the annual detour damages that would occur during the years when the highway was flooded. It also shows road restoration damages that can be expected when the lake recedes. Restoration damages include rebuilding the road with excavation, fill, surface material, and bridge repairs. Restoration damages are a per-event damage.

The lower portion of the table shows the breakdown of these summary values for each of the three action levels. It gives quantities in terms of miles per year (of extra miles traveled as a result of detours) and hours per year (of additional travel time resulting from detours) for the detour damages. Also shown are quantities and line-item damages for excavation, fabric liner, aggregate base course, and fill for road restoration work when waters recede.

Unit prices for all the damage computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for ND Highway 20 (ND Highway 57 to Tokio) are listed in the Feature 22 Assumptions listing, appended to this Section 2.22.

Costs: The costs of providing flood protection for ND Highway 20 (ND Highway 57 to Tokio) are detailed in the accompanying Table 2.22-2 for ND Highway 20 (ND Highway 57 to Tokio). Quantities and line-item totals are listed.

The top portion of the table gives the costs of providing flood protection (as represented in the analysis) by action level for all of the flood protection strategies. The lower portion of the table gives a breakdown of the quantities and costs by line item: fabric liner, aggregate base, fill, riprap, and bituminous pavement material.

Unit costs for all the cost computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for ND Highway 20 (ND Highway 57 to Tokio) are listed in the ND Highway 20 (ND Highway 57 to Tokio) Assumptions listing, appended to this Section 2.22.

2.22.4 Results of Economic Analysis

The results of the Economic Analysis for the ND Highway 20 (ND Highway 57 to Tokio) are listed in Table 2.22-3.

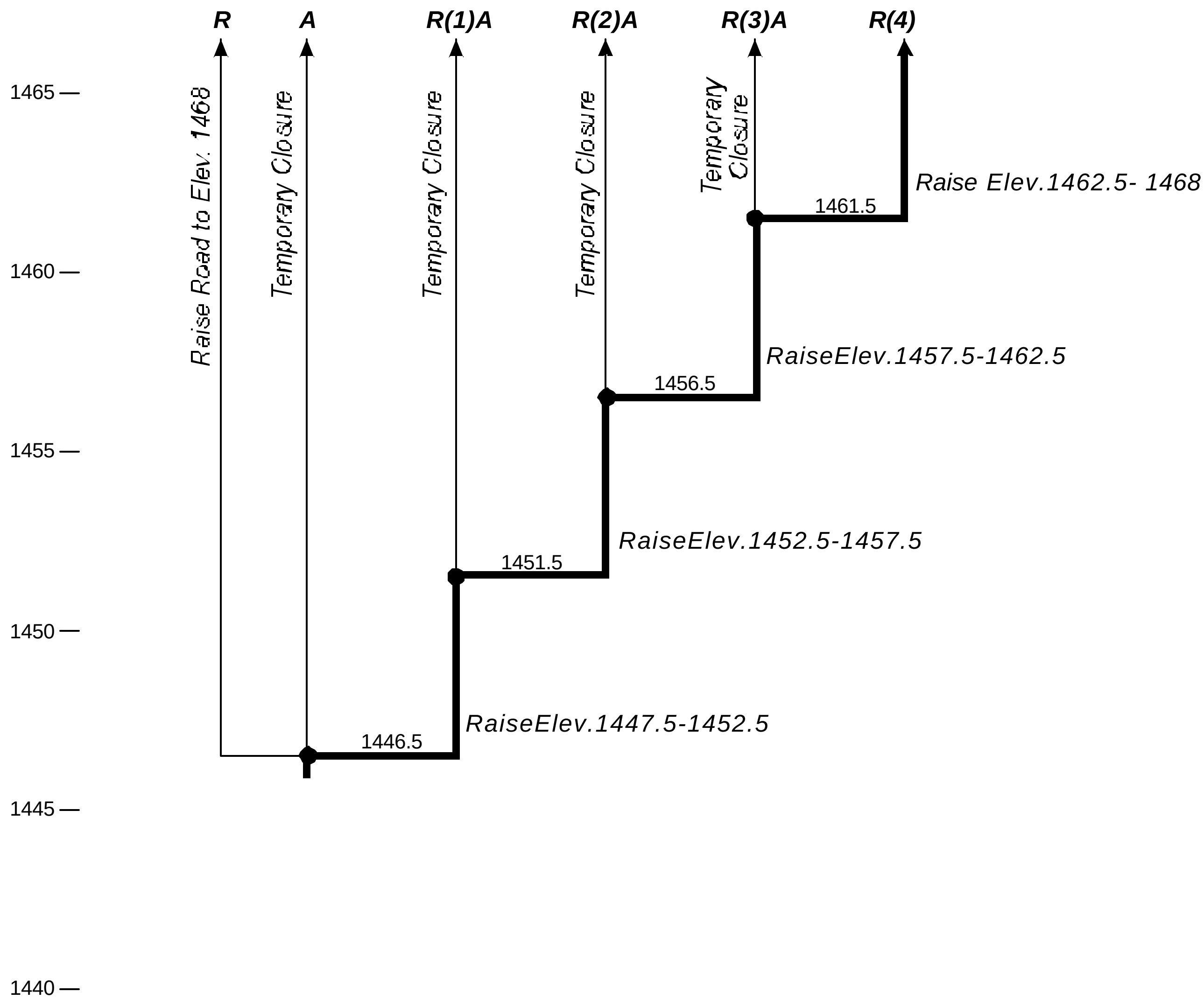
Stochastic Analysis Results: The flood protection strategy that was analyzed for protecting ND Highway 20 (ND Highway 57 to Tokio) was four incremental road raises. This strategy is highlighted on the decision tree (Figure 2.22-2). The average annual net benefits for this strategy were less than zero (-$1,273,600). The BCR for this strategy was less than one (0.35). These results indicate that this strategy was not economically justified. The present worth annualized detour damages that would be prevented by this strategy were computed to be $289,000. The stochastic results are averages over 10,000 traces.

Results for Specific Scenarios: In the economic analysis, flood protection strategies were also analyzed for three specific climate futures. For ND Highway 20 (ND Highway 57 to Tokio), the identified strategy and the economic indices for each of the three climate futures are as follows:

- Wet Future – For the wet future, the annual net benefits were -$3,053,800, and the BCR was 0.16, indicating that this strategy was not economically justified. For this future, the present worth annualized detour damages that would be prevented were computed at $576,000.
- First Moderate Future – For the first moderate future, the annual net benefits were -$561,300, and the BCR was 0.64, indicating that this strategy was not economically justified. For this future, the present worth annualized detour damages that would be prevented were computed at $294,500.
- Second Moderate Future – For the second moderate future, the annual net benefits were -$1,661,100, and the BCR was 0.26, indicating that this strategy was not economically justified. For this future, the present worth annualized detour damages that would be prevented were computed at $496,500.

Figure 2.22-1
LOCATION MAP
FEATURE 22: ND HIGHWAY 20
(ND HIGHWAY 57 TO TOKIO)
Devils Lake Infrastructure
Protection Study

DATA: 1997 USGS Digital Ortho Quad



Lowest RoadElevation:1447.5

P:3413\6120\DECISIONTREES\2012FIGURES\FIGURE2_22.CDR RLG 01-02-03

FloodProtectionStrategy

Decisionrequiredatthispoint

Triggerpointforaction,nodecisionneeded

R(1) Incrementalroad raise(number oftimes)

R Road raiseto1468

A Temporary closureofroad

Figure2.22-2

DECISION TREE
FEATURE 22:NDHIGHWAY20
(NDHighway57toTokio)
DevilsLakeInfrastructure ProtectionStudy

Table 2.22-1

Flood Damages
Feature 22: ND Highway 20 (ND Highway 57 and Tokio)
Devils Lake Infrastructure Protection Study

DAMAGES

Action Levels	Annual Detour Damages (THOUSANDS)
AL1 - AL4	$576

DAMAGE BREAKDOWN

Damage	AL1 - AL4 Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Annual Detour Damages	HWY 20				
	HR/YEAR	23,406	HR	$7.00	$164
	MILES/YEAR	1,287,324	MILE	$0.32	$412
	Total				$576

Restoration Damages

		Excavation				Fabric Liner				Aggregate Base Course				Fill				Bituminous Pavement				Bridge Repair			
Elevation	Total (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Cost (THOUSANDS)
1446	$0																								
1447	$6,836	190,560	CY	$2.65	$505	337,500	SY	$1.33	$449	41,023	CY	$21.20	$870	282,145	CY	$4.77	$1,346	76,859	TON	$47.70	$3,666	0	EA	$530,000	$0
1448	$6,836	190,560	CY	$2.65	$505	337,500	SY	$1.33	$449	41,023	CY	$21.20	$870	282,145	CY	$4.77	$1,346	76,859	TON	$47.70	$3,666	0	EA	$530,000	$0
1449	$6,836	190,560	CY	$2.65	$505	337,500	SY	$1.33	$449	41,023	CY	$21.20	$870	282,145	CY	$4.77	$1,346	76,859	TON	$47.70	$3,666	0	EA	$530,000	$0
1450	$6,836	190,560	CY	$2.65	$505	337,500	SY	$1.33	$449	41,023	CY	$21.20	$870	282,145	CY	$4.77	$1,346	76,859	TON	$47.70	$3,666	0	EA	$530,000	$0
1451	$6,836	190,560	CY	$2.65	$505	337,500	SY	$1.33	$449	41,023	CY	$21.20	$870	282,145	CY	$4.77	$1,346	76,859	TON	$47.70	$3,666	0	EA	$530,000	$0
1452	$6,836	190,560	CY	$2.65	$505	337,500	SY	$1.33	$449	41,023	CY	$21.20	$870	282,145	CY	$4.77	$1,346	76,859	TON	$47.70	$3,666	0	EA	$530,000	$0
1453	$6,836	190,560	CY	$2.65	$505	337,500	SY	$1.33	$449	41,023	CY	$21.20	$870	282,145	CY	$4.77	$1,346	76,859	TON	$47.70	$3,666	0	EA	$530,000	$0
1454	$6,836	190,560	CY	$2.65	$505	337,500	SY	$1.33	$449	41,023	CY	$21.20	$870	282,145	CY	$4.77	$1,346	76,859	TON	$47.70	$3,666	0	EA	$530,000	$0
1455	$6,836	190,560	CY	$2.65	$505	337,500	SY	$1.33	$449	41,023	CY	$21.20	$870	282,145	CY	$4.77	$1,346	76,859	TON	$47.70	$3,666	0	EA	$530,000	$0
1456	$8,084	225,360	CY	$2.65	$597	399,134	SY	$1.33	$531	48,515	CY	$21.20	$1,029	333,670	CY	$4.77	$1,592	90,895	TON	$47.70	$4,336	0	EA	$530,000	$0
1457	$8,084	225,360	CY	$2.65	$597	399,134	SY	$1.33	$531	48,515	CY	$21.20	$1,029	333,670	CY	$4.77	$1,592	90,895	TON	$47.70	$4,336	0	EA	$530,000	$0
1458	$8,084	225,360	CY	$2.65	$597	399,134	SY	$1.33	$531	48,515	CY	$21.20	$1,029	333,670	CY	$4.77	$1,592	90,895	TON	$47.70	$4,336	0	EA	$530,000	$0
1459	$8,084	225,360	CY	$2.65	$597	399,134	SY	$1.33	$531	48,515	CY	$21.20	$1,029	333,670	CY	$4.77	$1,592	90,895	TON	$47.70	$4,336	0	EA	$530,000	$0
1460	$8,084	225,360	CY	$2.65	$597	399,134	SY	$1.33	$531	48,515	CY	$21.20	$1,029	333,670	CY	$4.77	$1,592	90,895	TON	$47.70	$4,336	0	EA	$530,000	$0
1461	$8,084	225,360	CY	$2.65	$597	399,134	SY	$1.33	$531	48,515	CY	$21.20	$1,029	333,670	CY	$4.77	$1,592	90,895	TON	$47.70	$4,336	0	EA	$530,000	$0
1462	$8,614	225,360	CY	$2.65	$597	399,134	SY	$1.33	$531	48,515	CY	$21.20	$1,029	333,670	CY	$4.77	$1,592	90,895	TON	$47.70	$4,336	1	EA	$530,000	$530

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.

Table 2.22-2

Flood Protection Costs
Feature 22: ND Highway 20 (ND Highway 57 to Tokio)
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Action Level	Lake Elevation	R Maximum Raise at AL1	A Temporary Closure at AL1	R(1)A Raise at AL1; Temporary Closure at AL2	R(2)A Raise at AL1, AL2; Temporary Closure at AL3	R(3)A Raise at AL1, AL2, AL3; Temporary Closure at AL4	R(4) Raise at AL1, AL2, AL3, AL4
	(MSL)	(THOUSANDS)					
AL1	1446	$110,322	$0	$25,045	$25,045	$5,119	$5,119
AL2	1451	$0	$0	$0	$22,269	$4,607	$4,607
AL3	1456	$0	$0	$0	$0	$26,814	$26,814
AL4	1461	$0	$0	$0	$0	$0	$36,194

COST BREAKDOWN

R: R(1)A, R(2)A, R(3)A, R(4)A

Strategy		Lake Elevation 1446				
Incremental Raise		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
	Road Raise	ND Highway 20				
		Fabric Liner	516,693	SY	$1.33	$687
		Aggregate Ba:	41,023	CY	$21.20	$870
		Fill	1,049,844	CY	$9.00	$9,449
		Riprap	345,762	TON	$30.00	$10,373
		Bituminous	76,859	TON	$47.70	$3,666
		Bridge Repair	0	EA	$530,000	$0
		Subtotal				$25,045
		Total				**$25,045**

R: R(2)A, R(3)A, R(4)A

Strategy		Lake Elevation 1451				
Incremental Raise		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
	Road Raise	ND Highway 20				
		Fabric Liner	338,699	SY	$1.33	$450
		Aggregate Base	7,492	CY	$21.20	$159
		Fill	1,576,747	CY	$9.00	$14,191
		Riprap	226,652	TON	$30.00	$6,800
		Bituminous	14,036	TON	$47.70	$670
		Bridge Repair	0	EA	$530,000	$0
		Subtotal				$22,269
		Total				**$22,269**

R: R(3)A, R(4)A

Strategy		Lake Elevation 1456				
Incremental Raise		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
	Road Raise	ND Highway 20				
		Fabric Liner	317,998	SY	$1.33	$423
		Aggregate Base	0	CY	$21.20	$0
		Fill	2,164,067	CY	$9.00	$19,477
		Riprap	212,799	TON	$30.00	$6,384
		Bituminous	0	TON	$47.70	$0
		Bridge Repair	1	EA	$530,000	$530
		Subtotal				$26,814
		Total				**$26,814**

R: R(4)A

Strategy		Lake Elevation 1461				
Incremental Raise		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
	Road Raise	ND Highway 20				
		Fabric Liner	380,381	SY	$1.33	$506
		Aggregate Bas	3,531	CY	$21.20	$75
		Fill	3,014,584	CY	$9.00	$27,131
		Riprap	254,544	TON	$30.00	$7,636
		Bituminous	6,615	TON	$47.70	$316
		Bridge Repair	1	EA	$530,000	$530
		Subtotal				$36,194
		Total				**$36,194**

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. The costs for the Maximum Raise at AL1 strategy (R) is equal to the sum of the costs for all incremental raises.

Table 2.22 - 3

Economic Analysis of Strategies for Highway 20 between Highway 57 and Tokio (Feature 22)

Stochastic Analysis (ST)
Mean Value over 10,000 Traces (Annual)

Designation	Description	COSTS: Raise A	COSTS: Relocation B	COSTS: Total C = A + B	DAMAGES: Restoration D	DAMAGES: Detour E	DAMAGES: Relocation Detour F	DAMAGES: Total G = D + E + F	Total Benefits To Strategy (Damages Prevented) H = G(A) - G(S) *	Net Benefits To Strategy I = H - C	Benefit- Cost Ratio (BCR) I = H / C
A	Temporary Closure During Floods at First Action Lev	$0	$0	$0	$407,700	#######	$0	$696,700	$0	$0	--
R	Road Raise to 1468	########	$0	$6,926,700	$0	$0	$0	$0	$696,700	-$6,230,000	0.10
R(1)A	1 Road Raise: Then Temporary Closure During Floo	########	$0	$1,572,500	$61,800	$55,000	$0	$116,700	$580,000	-$992,500	0.37
R(2)A	2 Road Raises: Then Temporary Closure During Flo	########	$0	$1,832,200	$24,200	$16,200	$0	$40,400	$656,300	-$1,176,000	0.36
R(3)A	3 Road Raises: Then Temporary Closure During Flo	########	$0	$1,941,400	$5,300	$1,300	$0	$6,700	$690,100	-$1,251,400	0.36
R(4)	4 Incr. Road Raises	########	$0	$1,970,300	$0	$0	$0	$0	$696,700	-$1,273,600	0.35

Wet Future Scenario (WF)
(Annual)

Designation	Description	COSTS: Raise A	COSTS: Relocation B	COSTS: Total C = A + B	DAMAGES: Restoration D	DAMAGES: Detour E	DAMAGES: Relocation Detour F	DAMAGES: Total G = D + E + F	Total Benefits To Strategy (Damages Prevented) H = G(A) - G(S) *	Net Benefits To Strategy I = H - C	Benefit- Cost Ratio (BCR) I = H / C
A	Temporary Closure During Floods at First Action Lev	$0	$0	$0	$0	#######	$0	$576,000	$0	$0	--
R	Road Raise to 1468	########	$0	$6,926,700	$0	$0	$0	$0	$576,000	-$6,350,700	0.08
R(1)A	1 Road Raise: Then Temporary Closure During Floo	########	$0	$1,572,500	$99,300	#######	$0	$533,400	$42,600	-$1,529,900	0.03
R(2)A	2 Road Raises: Then Temporary Closure During Flo	########	$0	$2,664,500	$125,600	#######	$0	$385,400	$190,500	-$2,473,900	0.07
R(3)A	3 Road Raises: Then Temporary Closure During Flo	########	$0	$3,629,800	$0	$0	$0	$0	$576,000	-$3,053,800	0.16
R(4)	4 Incr. Road Raises	########	$0	$3,629,800	$0	$0	$0	$0	$576,000	-$3,053,800	0.16

Moderate Future 1 Scenario (M1)
(Annual)

Designation	Description	COSTS: Raise A	COSTS: Relocation B	COSTS: Total C = A + B	DAMAGES: Restoration D	DAMAGES: Detour E	DAMAGES: Relocation Detour F	DAMAGES: Total G = D + E + F	Total Benefits To Strategy (Damages Prevented) H = G(A) - G(S) *	Net Benefits To Strategy I = H - C	Benefit- Cost Ratio (BCR) I = H / C
A	Temporary Closure During Floods at First Action Lev	$0	$0	$0	$716,600	#######	$0	$1,011,200	$0	$0	--
R	Road Raise to 1468	########	$0	$6,926,700	$0	$0	$0	$0	$1,011,200	-$5,915,500	0.15
R(1)A	1 Road Raise: Then Temporary Closure During Floo	########	$0	$1,572,500	$0	$0	$0	$0	$1,011,200	-$561,300	0.64
R(2)A	2 Road Raises: Then Temporary Closure During Flo	########	$0	$1,572,500	$0	$0	$0	$0	$1,011,200	-$561,300	0.64
R(3)A	3 Road Raises: Then Temporary Closure During Flo	########	$0	$1,572,500	$0	$0	$0	$0	$1,011,200	-$561,300	0.64
R(4)	4 Incr. Road Raises	########	$0	$1,572,500	$0	$0	$0	$0	$1,011,200	-$561,300	0.64

Moderate Future 2 Scenario (M2)
(Annual)

Designation	Description	COSTS: Raise A	COSTS: Relocation B	COSTS: Total C = A + B	DAMAGES: Restoration D	DAMAGES: Detour E	DAMAGES: Relocation Detour F	DAMAGES: Total G = D + E + F	Total Benefits To Strategy (Damages Prevented) H = G(A) - G(S) *	Net Benefits To Strategy I = H - C	Benefit- Cost Ratio (BCR) I = H / C
A	Temporary Closure During Floods at First Action Lev	$0	$0	$0	$80,900	#######	$0	$577,500	$0	$0	--
R	Road Raise to 1468	########	$0	$6,926,700	$0	$0	$0	$0	$577,500	-$6,349,300	0.08
R(1)A	1 Road Raise: Then Temporary Closure During Floo	########	$0	$1,572,500	$150,100	$89,000	$0	$239,200	$338,300	-$1,234,200	0.22
R(2)A	2 Road Raises: Then Temporary Closure During Flo	########	$0	$2,238,500	$0	$0	$0	$0	$577,500	-$1,661,100	0.26
R(3)A	3 Road Raises: Then Temporary Closure During Flo	########	$0	$2,238,500	$0	$0	$0	$0	$577,500	-$1,661,100	0.26
R(4)	4 Incr. Road Raises	########	$0	$2,238,500	$0	$0	$0	$0	$577,500	-$1,661,100	0.26

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.375% and rounded to the nearest $100.
* Total benefits are calculated as the total damages incurred for "temporary closure strategy" minus the total damages for the strategy implemented (G(S)).
The "No Protection" strategy for roads has been defined as temporary closure during floods at the first action level with restoration when the lake recedes.

Attachment to 2.22:
ND Highway 20 (ND Highway 57 to Tokio) Economic Analysis Assumptions

1. Plans for 2001 include raising portions of Highway 20 from a minimum elevation of 1447.5 to 1455 and the bridge across Devils Lake from 1443.5 to 1461 (low chord). For this analysis, the work was assumed completed and the new elevations were used.

A. General Assumptions

1. Decisions were assumed to occur when the lake level is within (or predicted by the National Weather Service to be within) 1 foot of the lowest road elevation. This assumption is consistent with current practices in the area as dictated by funding agencies. In the past, funding for road raises has not been available until the National Weather Service predicts on February 15th that the road will go under water during that year.

2. If the road includes a bridge having a low chord elevation below the lowest road elevation, it was assumed that no decision would occur until the lake level was within 1 foot of the lowest road elevation. This assumption follows current practices in the area.

B. Road Raises

1. Road raise costs were calculated in the manner presented in a previous study (*Devils Lake Flood Control: Economics Database Update: Transportation Report*, Barr Engineering Company, January 1998). Unit costs for construction materials were updated for inflation by multiplying them by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001. Additionally the cost of riprap and fill were increased from $20 to $30 and $4.50 to $9.00, respectively. Based on conversations with the
   Engineers the new costs for riprap and fill are more representative of the costs in the area.

2. The last road raise was assumed to be to elevation 1468. At this elevation, roads would be 5 feet above the assumed maximum lake level (elevation 1463).

3. The final incremental road raise (to elevation 1468) was assumed to be no more than 8 feet and no less than 4 feet.

C. Temporary Road Closure During Floods

1. It was assumed that if a road was temporarily closed, it would be restored after the lake level has receded 1 foot below the top of road. All of the road features in this study are highly traveled. It is very likely that people would want to use these roads again if the lake level receded after flooding,

assuming that communities, businesses, farmsteads, and residents continue to generate the same level of traffic as at present.

2. Restoration damages were calculated in the manner presented in *Devils Lake Flood Control: Economics Database Update: Transportation Report*, Barr Engineering Company, January 1998. Unit costs for construction materials were updated for inflation by multiplying them by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001.

3. Detour damages were included for every year that a road is temporarily closed, as well as for the first year that the lake has receded. It was assumed that during the first year after the lake has receded, the road would be under restoration. During this first year, there would be both a detour damage and restoration damage. After this first year, there would be no further detour or restoration damages unless the lake rises to within 1 foot of the road again.

4. Restoration of a road would only occur after the lake has receded to 1 foot below the lowest elevation in that road. This was based on the assumption that restoration would only occur when there is no water on any part of the road and there would be only minor potential for wave action damage on the road.

5. Detour damages were calculated using a cost of $7 per hour of additional travel time, 1.5 people per vehicle, and $0.32 per mile for additional travel distance (Corps of Engineers, March, 2001). Additional time and miles traveled were taken from the results of the QRS II model used in *Devils Lake Flood Control: Economics Database Update: Transportation Report*, Barr Engineering Company, January 1998. The QRS II model determines the overall effect of a closed road on an entire network of traffic, incorporating the fact that traffic consists of trips having different origins and destinations.

6. There is more commitment on the part of the North Dakota Department of Transportation (NDDOT) to the Highway 57 causeway than to the Highway 20 causeway through The Narrows. Therefore, Highway 57 was assumed to be the detour route for the Highway 20 causeway. If the Highway 57 causeway was temporarily closed during flooding, it was assumed that the Highway 20 causeway would also be temporarily closed.

7. The detour route for Highway 57 is around the lake to the west via Highway 281 and Highway 19. Woods-Rutten Road was considered as a detour route for Highway 57, but it was not retained as a viable alternative, because it would have to be significantly raised and improved to carry the traffic of Highway 57.

8. Detour paths were determined assuming that all other featured roads would be open (with three exceptions: the Highway 57 detour assumes that Highway 20 across The Narrows is closed and both

the BIA 1 and the BIA 6 detours assume that Highway 20 from Highway 57 to Tokio is closed). No effort was made to link detour routes with lake level. However, if a featured road was presented as a detour route, an "interdependency" was noted.

9. The analysis of Features 23 (BIA 1 between Highway 57 and BIA 6) and Feature 24 (BIA 6 between Highway 20 and Fort Totten) assumed that Feature 22 (Highway 20 between Highway 57 and Tokio) is temporarily closed during high lake levels. BIA 1 and BIA 6 are part of the north-south detour for Highway 20 and the preliminary analysis indicated that Feature 22 would likely be temporarily closed during high lake levels.

10. Two features can have mutually interdependent detour routes if they are the most reasonable detours. In these cases, it was assumed that either the analyzed feature or the other feature would be raised or rerouted. In these cases, the interdependency was noted.

D. Road Reroutes

1. No logical reroute was identified for this feature.

2.23 Summary of Economic Analysis Investigation for Feature 23: BIA Highway 1

2.23.0 Flood Protection Strategy

The flood protection strategy that was analyzed in the Economic Analysis of Devils Lake Alternatives for BIA Highway 1 was incremental road raises.

2.23.1 General Information

Feature Type: Road

Location: BIA Highway 1 is located in Sections 7, 8, and 17 of Mission Township, Benson County and on the Spirit Lake Nation Reservation. The feature extends 2.72 miles between ND Highway 57 at the northwest to Highway BIA 6 to the southeast. The accompanying Figure 2.23-1 shows the feature's location and extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: BIA Highway 1 is a two-lane bituminous-surfaced federal highway. The centerline elevation varies from 1450.5 to 1487.5, and crosses Mission Bay (a portion of Devils Lake) at its northwest end. A portion of the roadway is currently acting as a dam (see analysis of Feature 25).

Significance: BIA Highway 1 is important because it is the major northbound and southbound route to and from the town of St. Michael and surrounding areas.

Damages: The flooding of BIA Highway 1 would result in the following damages:

- Detour damages resulting from the added travel time and miles traveled when BIA Highway 1 is closed and traffic is detoured
- Restoration damages resulting from repairs that would be necessary to bring the highway back to a useable condition after a period of inundation

Owner/Sponsor: The US Department of Interior, Bureau of Indian Affairs, is responsible for managing and maintaining BIA Highway 1.

Lead Federal Agency: The Bureau of Indian Affairs would take the lead for BIA Highway 1 in any flood protection work that may take place.

2.23.2 Feature Protection

History of Flood Protection: In the past, flood protection for BIA Highway 1 has consisted of raising the road to keep it from being overtopped.

General Protection Strategy: The analysis identified and evaluated one approach for protecting BIA Highway 1: incremental road raises.

Protection Strategy by Lake Level: The Economic Analysis of Devils Lake Alternatives evaluated this protection strategies, with flood protection decisions being made at various lake levels as Devils Lake continued to rise. Figure 2.23-2 shows the decision tree for BIA Highway 1. As shown on Figure 2.23-2, the stepwise approach to flood protection for BIA Highway 1 that was analyzed consisted of the following:

1. At lake elevation 1449.5, a decision would be made as to whether the road would be raised to 1455.5, or temporarily closed.
2. If the road were raised at the first action level, at lake elevation 1454.5 another decision would be made as to whether the road would be raised to 1460.5, or temporarily closed.
3. If the road were raised at the second action level, at lake elevation 1459.5 another decision would be made as to whether the road would be raised to 1468, or temporarily closed.

The maximum protection strategy that was analyzed at the first action level was raising the road to 1468. (Note that for the analysis, the decision regarding whether or not to raise the road is made at a time when the lake is one foot below the minimum highway elevation that resulted from the most recent raise.)

Interdependencies: The protection of BIA Highway 1 is related to the protection of several other features:

- Feature 5: St. Michael – BIA Highway 1 is the major road for traffic entering or leaving St. Michael. Therefore, decisions regarding flood protection in St. Michael are dependent on flood protection for BIA Highway 1.
- Feature 22: ND Highway 20 (ND Highway 57 to Tokio) – If ND Highway 20 (ND Highway 57 to Tokio) is temporarily closed, BIA Highway 1 becomes critical for carrying north-south traffic in the Devils Lake area.

Table 2.0-1, mentioned earlier in this report, provides a summary of the interdependencies among the features.

2.23.3 Feature Economics

Damages: For BIA Highway 1, the damages resulting from flooding were estimated up to the maximum lake level (1463). The damage computations for BIA Highway 1 are summarized in the accompanying Table 2.23-1.

The top portion of Table 2.23-1 gives a summary of the annual detour damages that would occur during the years when the highway was flooded. It also shows road restoration damages that can be expected when the lake recedes. Restoration damages include rebuilding the road with excavation, fill, surface material, and bridge repairs. Restoration damages are a per-event damage.

The lower portion of the table shows the breakdown of these summary values for each of the three action levels. It gives quantities in terms of miles per year (of extra miles traveled as a result of detours) and hours per year (of additional travel time resulting from detours) for the detour damages. Also shown are quantities and line-item damages for excavation, fabric liner, aggregate base course, and fill for road restoration work when waters recede.

Unit prices for all the damage computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for BIA Highway 1 are listed in the BIA Highway 1 Assumptions listing, appended to this Section 2.23.

Costs: The costs of providing flood protection for BIA Highway 1 are detailed in the accompanying Table 2.23-2 for BIA Highway 1. Quantities and line-item totals are listed.

The top portion of the table gives the costs of providing flood protection (as represented in the analysis) by action level for all of the five flood protection strategies. The lower portion of the table gives a breakdown of the quantities and costs by line item: fabric liner, aggregate base, fill, riprap, and bituminous pavement material.

Unit costs for all the cost computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for BIA Highway 1 are listed in the BIA Highway 1 Assumptions listing, appended to this Section 2.23.

2.23.4 Results of Economic Analysis

The results of the Economic Analysis for the BIA Highway 1 are listed in Table 2.23-3.

Stochastic Analysis Results: The flood protection strategy that was analyzed for protecting BIA Highway 1 was three incremental road raises. This strategy is highlighted on the decision tree (Figure 2.23-2). The average annual net benefits for this strategy were greater than zero ($14,400). The BCR for this strategy was greater than one (1.09). These results indicate that this strategy was economically justified. The present worth annualized detour damages that would be prevented by this strategy were computed to be $158,600. The stochastic results are averages over 10,000 traces.

Results for Specific Scenarios: In the economic analysis, flood protection strategies were also analyzed for three specific climate futures. For BIA Highway 1, the identified strategy and the economic indices for each of the three climate futures are as follows:

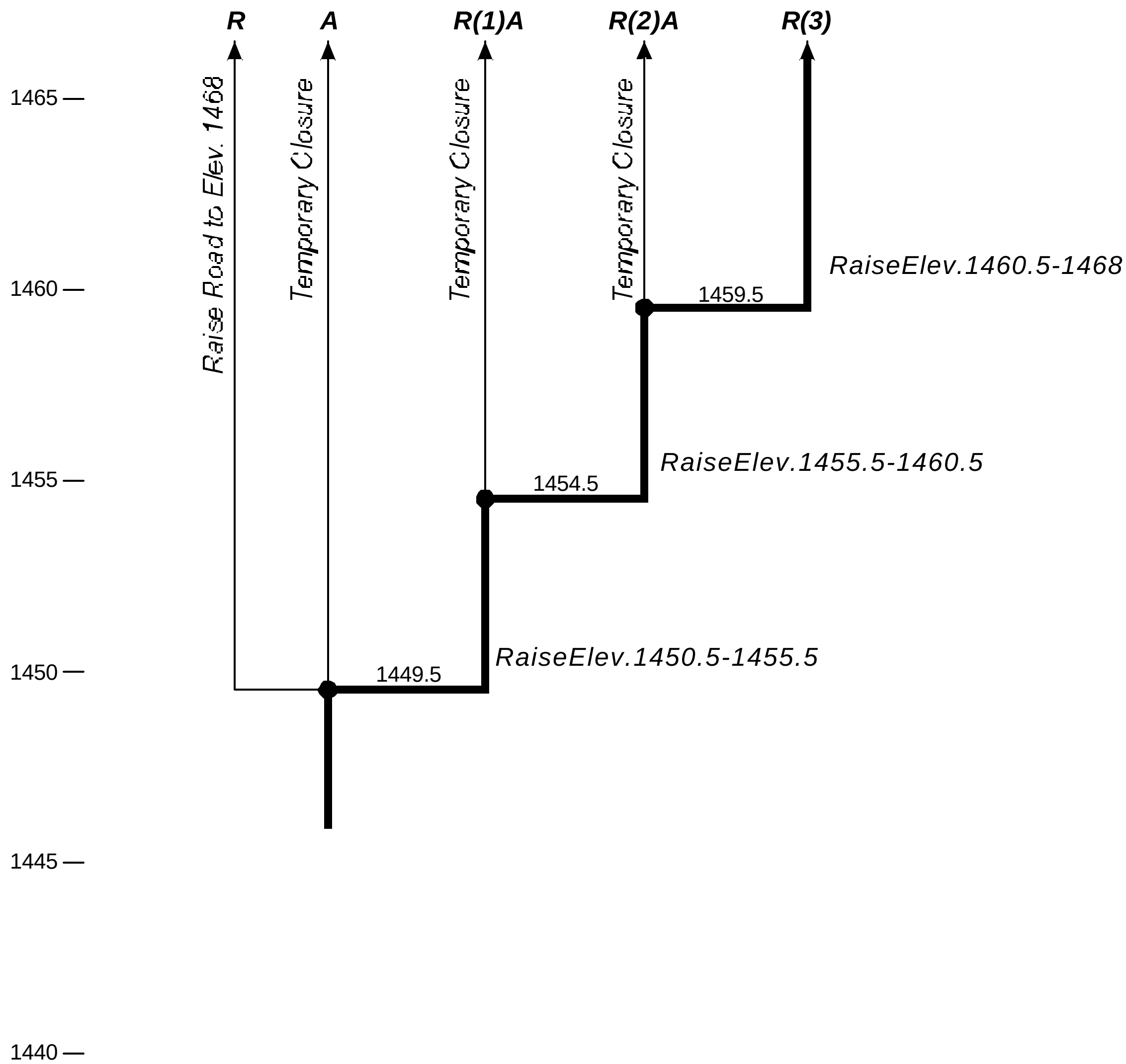
- Wet Future – For the wet future, the annual net benefits were $136,900, and the BCR was 1.20, indicating that this strategy was economically justified. For this future, the present worth annualized detour damages that would be prevented were computed at $838,700.
- First Moderate Future – For the first moderate future, the annual net benefits were -$72,200, and the BCR was 0.50, indicating that this strategy was not economically justified. For this future, the present worth annualized detour damages that would be prevented were computed at $52,100.
- Second Moderate Future – For the second moderate future, the annual net benefits were $92,800, and the BCR was 1.25, indicating that this strategy was economically justified. For this future, the present worth annualized detour damages that would be prevented were computed at $443,900.

Figure 2.23-1

LOCATION MAP
FEATURE 23: BIA HIGHWAY 1
Devils Lake Infrastructure
Protection Study

Data: 1997 USGS Digital Ortho Quad

Barr: Arcview 3.1 PIIIAF, i:\client\devilslake\gis\dlip\features\roadandtrails\roads\23_bia1\project\basemap_23.apr, Layout: Layout: Section 2 Figure, lkp, Tue Oct 29 17:16:13 2002



Lowest RoadElevation:1450.5

FloodProtectionStrategy

Decisionrequiredatthispoint

Triggerpointforaction,nodecisionneeded

R(1) Incrementalroad raise(number oftimes)

R Road raiseto1468

A Temporary closureofroad

Figure2.23-2

DECISION TREE
FEATURE 23:BIAHIGHWAY1
DevilsLakeInfrastructure ProtectionStudy

P:\3436\20\DECISIONTREES\2002FIGURES\FIGURE2_23.CDR RLG 01-02-03

Table 2.23-1

Flood Damages
Feature 23: BIA Highway 1
Devils Lake Infrastructure Protection Study

DAMAGES

Action Levels	Annual Detour Damages	Restoration Damages
	(THOUSANDS)	
AL1 - AL3	$955	$742

DAMAGE BREAKDOWN

Damage	AL1 - AL3				
	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Annual Detour Damages	BIA Highway 1				
	HR/YEAR	38,756	HR	$7.00	$271
	MILES/YEAR	2,131,593	MILE	$0.32	$682
	Total				$953
	2001 Adjusted Total				**$955**
Restoration Damages	BIA Highway 1				
	Excavation	44,645	CY	$2.65	$118
	Fabric Liner	79,423	SY	$1.33	$106
	Aggregate Base Course	9,567	CY	$21.20	$203
	Fill	35,078	CY	$9.00	$316
	Total				**$742**

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. 2001 Adjusted Total adjusts detailed damage breakdown to match the 2001 totals.

Table 2.23-2

Flood Protection Costs
Feature 23: BIA Highway 1
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Action Level	Lake Elevation	R Maximum Raise at AL1	A Temporary Closure at AL1	R(1)A Raise at AL1; Temporary Closure at AL2	R(2)A Raise at AL1, AL2; Temporary Closure at AL3	R(3) Raise at AL1, AL2, AL3
	(MSL)	(THOUSANDS)				
AL1	1449	$18,430	$0	$5,119	$5,119	$5,119
AL2	1454	$0	$0	$0	$4,607	$4,607
AL3	1459	$0	$0	$0	$0	$8,704

COST BREAKDOWN

		R														
		R(1)A														
		R(2)A					R(2)A									
		R(3)A					R(3)A					R(3)A				
		Lake Elevation 1449					Lake Elevation 1454					Lake Elevation 1459				
Strategy		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Incremental Raise																
	Road Raise	BIA Highway 1					BIA Highway 1					BIA Highway 1				
		Fabric Liner	124,633	SY	$1.33	$166	Fabric Liner	65,493	SY	$1.33	$87	Fabric Liner	98,241	SY	$1.33	$131
		Aggregate Bas	9,567	CY	$21.20	$203	Aggregate Base	0	CY	$21.20	$0	Aggregate Base	0	CY	$21.20	$0
		Fill	249,796	CY	$9.00	$2,248	Fill	356,093	CY	$9.00	$3,205	Fill	733,444	CY	$9.00	$6,601
		Riprap	83,402	TON	$30.00	$2,502	Riprap	43,827	TON	$30.00	$1,315	Riprap	65,741	TON	$30.00	$1,972
		Bituminous	0	TON	$47.70	$0	Bituminous	0	TON	$47.70	$0	Bituminous	0	TON	$47.70	$0
		Subtotal				$5,119	Subtotal				$4,607	Subtotal				$8,704
		Total				**$5,119**	**Total**				**$4,607**	**Total**				**$8,704**

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. The costs for the Maximum Raise at AL1 strategy (R) is equal to the sum of the costs for all incremental raises.

Table 2.23 - 3

Economic Analysis of Strategies for
BIA 1 between Highway 57 and BIA 6
(Feature 23)

Stochastic Analysis (ST)
Mean Value over 10,000 Traces (Annual)

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Relocation	Total	Restoration	Detour	Relocation Detour	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C = A + B	D	E	F	G = D + E + F	H = G(A) - G(S) *	I = H - C	J = H / C
A	Temporary Closure During Floods at First Action	$0	$0	$0	$13,800	#######	$0	$172,400	$0	$0	--
R	Road Raise to 1468	$404,400	$0	$404,400	$0	$0	$0	$0	$172,400	-$232,000	0.43
R(1)A	1 Road Raise: Then Temporary Closure During F	$112,300	$0	$112,300	$3,100	$44,700	$0	$47,900	$124,500	$12,200	1.11
R(2)A	2 Road Raises: Then Temporary Closure During	$140,500	$0	$140,500	$1,300	$9,300	$0	$10,600	$161,800	$21,300	1.15
R(3)	3 Incr. Road Raises	$158,000	$0	$158,000	$0	$0	$0	$0	$172,400	$14,400	1.09

Wet Future Scenario (WF)
(Annual)

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Relocation	Total	Restoration	Detour	Relocation Detour	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C = A + B	D	E	F	G = D + E + F	H = G(A) - G(S) *	I = H - C	J = H / C
A	Temporary Closure During Floods at First Action	$0	$0	$0	$0	#######	$0	$838,700	$0	$0	--
R	Road Raise to 1468	########	$0	$1,022,500	$0	$0	$0	$0	$838,700	-$183,900	0.82
R(1)A	1 Road Raise: Then Temporary Closure During F	$284,100	$0	$284,100	$10,300	#######	$0	$552,900	$285,700	$1,700	1.01
R(2)A	2 Road Raises: Then Temporary Closure During	$471,700	$0	$471,700	$10,600	#######	$0	$218,300	$620,300	$148,600	1.32
R(3)	3 Incr. Road Raises	$701,800	$0	$701,800	$0	$0	$0	$0	$838,700	$136,900	1.20

Moderate Future 1 Scenario (M1)
(Annual)

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Relocation	Total	Restoration	Detour	Relocation Detour	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C = A + B	D	E	F	G = D + E + F	H = G(A) - G(S) *	I = H - C	J = H / C
A	Temporary Closure During Floods at First Action	$0	$0	$0	$19,600	$52,100	$0	$71,700	$0	$0	--
R	Road Raise to 1468	$518,100	$0	$518,100	$0	$0	$0	$0	$71,700	-$446,400	0.14
R(1)A	1 Road Raise: Then Temporary Closure During F	$143,900	$0	$143,900	$0	$0	$0	$0	$71,700	-$72,200	0.50
R(2)A	2 Road Raises: Then Temporary Closure During	$143,900	$0	$143,900	$0	$0	$0	$0	$71,700	-$72,200	0.50
R(3)	3 Incr. Road Raises	$143,900	$0	$143,900	$0	$0	$0	$0	$71,700	-$72,200	0.50

Moderate Future 2 Scenario (M2)
(Annual)

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Relocation	Total	Restoration	Detour	Relocation Detour	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C = A + B	D	E	F	G = D + E + F	H = G(A) - G(S) *	I = H - C	J = H / C
A	Temporary Closure During Floods at First Action	$0	$0	$0	$14,400	#######	$0	$458,200	$0	$0	--
R	Road Raise to 1468	$849,500	$0	$849,500	$0	$0	$0	$0	$458,200	-$391,200	0.54
R(1)A	1 Road Raise: Then Temporary Closure During F	$236,000	$0	$236,000	$19,600	$52,100	$0	$71,700	$386,600	$150,600	1.64
R(2)A	2 Road Raises: Then Temporary Closure During	$365,500	$0	$365,500	$0	$0	$0	$0	$458,200	$92,800	1.25
R(3)	3 Incr. Road Raises	$365,500	$0	$365,500	$0	$0	$0	$0	$458,200	$92,800	1.25

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.375% and rounded to the nearest $100.
* Total benefits are calculated as the total damages incurred for "temporary closure strategy" minus the total damages for the strategy implemented (G(S)).
The "No Protection" strategy for roads has been defined as temporary closure during floods at the first action level with restoration when the lake recedes.

Attachment to 2.23:
BIA Highway 1 Economic Analysis Assumptions

No feature-specific assumptions were made for Feature 23.

A. General Assumptions

1. Decisions were assumed to occur when the lake level is within (or predicted by the National Weather Service to be within) 1 foot of the lowest road elevation. This assumption is consistent with current practices in the area as dictated by funding agencies. In the past, funding for road raises has not been available until the National Weather Service predicts on February 15th that the road will go under water during that year.

2. If the road includes a bridge having a low chord elevation below the lowest road elevation, it was assumed that no decision would occur until the lake level was within 1 foot of the lowest road elevation. This assumption follows current practices in the area.

B. Road Raises

1. Road raise costs were calculated in the manner presented in a previous study (*Devils Lake Flood Control: Economics Database Update: Transportation Report*, Barr Engineering Company, January 1998). Unit costs for construction materials were updated for inflation by multiplying them by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001. Additionally the cost of riprap and fill were increased from $20 to $30 and $4.50 to $9.00, respectively. Based on conversations with the NDDOT, railroad companies, and the Corps of Engineers the new costs for riprap and fill are more representative of the costs in the area.

2. The last road raise was assumed to be to elevation 1468. At this elevation, roads would be 5 feet above the assumed maximum lake level (elevation 1463).

3. The final incremental road raise (to elevation 1468) was assumed to be no more than 8 feet and no less than 4 feet.

4. Bureau of Indian Affairs (BIA) roads were assumed to be raised in 5-foot increments (*Devils Lake Flood Control: Economics Database Update: Transportation Report,* Barr Engineering Company, January 1998).

C. Temporary Road Closure During Floods

1. It was assumed that if a road was temporarily closed, it would be restored after the lake level has receded 1 foot below the top of road. All of the road features in this study are highly traveled. It is very likely that people would want to use these roads again if the lake level receded after flooding,

assuming that communities, businesses, farmsteads, and residents continue to generate the same level of traffic as at present.

2. Restoration damages were calculated in the manner presented in *Devils Lake Flood Control: Economics Database Update: Transportation Report*, Barr Engineering Company, January 1998. Unit costs for construction materials were updated for inflation by multiplying them by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001.

3. Detour damages were included for every year that a road is temporarily closed, as well as for the first year that the lake has receded. It was assumed that during the first year after the lake has receded, the road would be under restoration. During this first year, there would be both a detour damage and restoration damage. After this first year, there would be no further detour or restoration damages unless the lake rises to within 1 foot of the road again.

4. Restoration of a road would only occur after the lake has receded to 1 foot below the lowest elevation in that road. This was based on the assumption that restoration would only occur when there is no water on any part of the road and there would be only minor potential for wave action damage on the road.

5. Detour damages were calculated using a cost of $7 per hour of additional travel time, 1.5 people per vehicle, and $0.32 per mile for additional travel distance (Corps of Engineers, March, 2001). Additional time and miles traveled were taken from the results of the QRS II model used in *Devils Lake Flood Control: Economics Database Update: Transportation Report*, Barr Engineering Company, January 1998. The QRS II model determines the overall effect of a closed road on an entire network of traffic, incorporating the fact that traffic consists of trips having different origins and destinations.

6. There is more commitment on the part of the North Dakota Department of Transportation (NDDOT) to the Highway 57 causeway than to the Highway 20 causeway through The Narrows. Therefore, Highway 57 was assumed to be the detour route for the Highway 20 causeway. If the Highway 57 causeway was temporarily closed during flooding, it was assumed that the Highway 20 causeway would also be temporarily closed.

7. The detour route for Highway 57 is around the lake to the west via Highway 281 and Highway 19. Woods-Rutten Road was considered as a detour route for Highway 57, but it was not retained as a viable alternative, because it would have to be significantly raised and improved to carry the traffic of Highway 57.

8. Detour paths were determined assuming that all other featured roads would be open (with three exceptions: the Highway 57 detour assumes that Highway 20 across The Narrows is closed and both

the BIA 1 and the BIA 6 detours assume that Highway 20 from Highway 57 to Tokio is closed). No effort was made to link detour routes with lake level. However, if a featured road was presented as a detour route, an "interdependency" was noted.

9. The analysis of Features 23 (BIA 1 between Highway 57 and BIA 6) and Feature 24 (BIA 6 between Highway 20 and Fort Totten) assumed that Feature 22 (Highway 20 between Highway 57 and Tokio) is temporarily closed during high lake levels. BIA 1 and BIA 6 are part of the north-south detour for Highway 20 and the preliminary analysis indicated that Feature 22 would likely be temporarily closed during high lake levels.

10. Two features can have mutually interdependent detour routes if they are the most reasonable detours. In these cases, it was assumed that either the analyzed feature or the other feature would be raised or rerouted. In these cases, the interdependency was noted.

D. Road Reroutes

1. No logical reroute was identified for Feature 23.

2.24 Summary of Economic Analysis Investigation for Feature 24: BIA Highway 6

2.24.0 Flood Protection Strategy

The flood protection strategy that was analyzed in the Economic Analysis of Devils Lake Alternatives for BIA Highway 6 was incremental road raises.

2.24.1 General Information

Feature Type: Road

Location: Feature 24 is the 9-mile portion of BIA Highway 6 between Fort Totten at the west and ND Highway 20 at the east, and is located in Mission Township, Benson County. The accompanying Figure 2.24-1 shows the feature's location and approximate extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: BIA Highway 6 is a two-lane bituminous-surfaced federal highway. The centerline elevation varies from 1625.0 just east of Fort Totten to 1444 just west of ND Highway 20. BIA Highway 6 is currently being protected by roads that are acting as dams (see analysis of Feature 25).

Significance: BIA Highway 6 is important because it is a major traffic route in the area, including the main route between Fort Totten and St. Michael.

Damages: The flooding of BIA Highway 6 would result in the following damages:

- Detour damages resulting from the added travel time and miles traveled when BIA Highway 6 is closed and traffic is detoured. The detour damages for BIA Highway 6 assume that ND Highway 57 and ND Highway 20 are closed, and traffic is routed around the lake (for further description, see Section 2.24.3).

- Restoration damages resulting from repairs that would be necessary to bring the highway back to a useable condition after a period of inundation.

Owner/Sponsor: The US Department of Interior, Bureau of Indian Affairs, is responsible for managing and maintaining BIA Highway 6.

Lead Federal Agency: The Bureau of Indian Affairs would take the lead for BIA Highway 6 in any flood protection work that may take place.

2.24.2 Feature Protection

History of Flood Protection: No direct flood protection measures have been implemented for BIA Highway 6.

General Protection Strategy: The analysis identified and evaluated one approach for protecting BIA Highway 6: incremental road raises.

Protection Strategy by Lake Level: The Economic Analysis of Devils Lake Alternatives evaluated this protection strategy, with flood protection decisions being made at various lake levels as Devils Lake continued to rise. Figure 2.24-2 shows the decision tree for BIA Highway 6. As shown on Figure 2.24-2, the stepwise approach to flood protection for BIA Highway 6 that was analyzed consisted of the following:

1. When the interior water elevation behind the roads acting as dams rises to 1443 (or are no longer protecting this feature), a decision would be made as to whether the road would be raised to 1449, or temporarily closed.
2. If the road were raised at the first action level, at lake elevation 1448 another decision would be made as to whether the road would be raised to 1454, or temporarily closed.
3. If the road were raised at the second action level, at lake elevation 1453 another decision would be made as to whether the road would be raised to 1459, or temporarily closed.
4. If the road were raised at the third action level, at lake elevation 1458 another decision would be made as to whether the road would be raised to 1464, or temporarily closed.
5. If the road were raised at the fourth action level, at lake elevation 1463 another decision would be made as to whether the road would be raised to 1468, or temporarily closed.

The maximum protection strategy that was analyzed at the first action level was raising the road to 1468. (Note that for the analysis, the decision regarding whether or not to raise the road is made at a time when the lake is one foot below the minimum highway elevation that resulted from the most recent raise.)

Interdependencies: The protection of BIA Highway 6 is related to the protection of several other features:

- Feature 3: Fort Totten – BIA Highway 6 is a major road for traffic entering or leaving Fort Totten. Therefore, decisions regarding flood protection in Fort Totten are dependent on flood protection for BIA Highway 6.

- Feature 5: St. Michael – The BIA Highway 6 connection with BIA Highway 1 provides a major route for traffic entering or leaving St. Michael. Therefore, decisions regarding flood protection in St. Michael are dependent on flood protection for BIA Highway 6.
- Feature 13: US Highway 2 – If US Highway 2 is temporarily closed, traffic on BIA Highway 6 may increase as a detour route.
- Feature 14: ND Highway 57 (between ND Highway 20 and BIA Highway 1) – If ND Highway 57 is temporarily closed, traffic on BIA Highway 6 would increase as a detour route.
- Feature 15: ND Highway 57 (between BIA Highway 1 and US Highway 281) – If ND Highway 57 is temporarily closed, traffic on BIA Highway 6 would increase as a detour route.
- Feature 16: US Highway 281 (South of US Highway 2) – If US Highway 281 is temporarily closed, traffic on BIA Highway 6 would increase as a detour route.
- Feature 21: ND Highway 20 (City of Devils Lake Levee to ND Highway 27) – If ND Highway 20 is temporarily closed, BIA Highway 6 becomes critical for carrying north-south traffic in the Devils Lake area.
- Feature 22: ND Highway 20 (ND Highway 57 to Tokio) – If ND Highway 20 is temporarily closed, BIA Highway 6 becomes critical for carrying north-south traffic in the Devils Lake area.

Table 2.0-1, mentioned earlier in this report, provides a summary of the interdependencies among the features.

2.24.3 Feature Economics

Damages: For BIA Highway 6, the damages resulting from flooding were estimated up to the maximum lake level (1463). The damage computations for BIA Highway 6 are summarized in the accompanying Table 2.24-1.

The top portion of Table 2.24-1 gives a summary of the annual detour damages that would occur during the years when the highway was flooded. It also shows road restoration damages that can be expected when the lake recedes. Restoration damages include rebuilding the road with excavation, fill, surface material, and bridge repairs. Restoration damages are a per-event damage.

The detour damages for BIA Highway 6 assume that Feature 22, ND Highway 20 (ND Highway 57 to Tokio), is closed, and traffic is routed around the lake if BIA Highway 6 is temporarily closed. This was one of the four features in the Economics Analysis that was credited with the large detour damages around the lake (See discussion in Section 2.0.1.5). The computation of basin-wide damages required certain assumptions regarding interdependent roads in order to ensure that the basin-wide Economic Analysis was accurately representing overall traffic patterns. BIA Highway 6 was assigned the large detour damages because the roadway was less expensive to raise than ND Highway 20, and temporary closure of both segments would cause large detours.

The lower portion of the table shows the breakdown of these summary values for each of the three action levels. It gives quantities in terms of miles per year (of extra miles traveled as a result of detours) and hours per year (of additional travel time resulting from detours) for the detour damages. Also shown are quantities and line-item damages for excavation, fabric liner, aggregate base course, and fill for road restoration work when waters recede.

Unit prices for all the damage computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for BIA Highway 6 are listed in the Feature 24 Assumptions listing, appended to this Section 2.24.

Costs: The costs of providing flood protection for BIA Highway 6 are detailed in the accompanying Table 2.24-2 for BIA Highway 6. Quantities and line-item totals are listed.

The top portion of the table gives the costs of providing flood protection (as represented in the analysis) by action level for all of the five flood protection strategies. The lower portion of the table gives a breakdown of the quantities and costs by line item: fabric liner, aggregate base, fill, riprap, and bituminous pavement material.

Unit costs for all the cost computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for BIA Highway 6 are listed in the Feature Assumptions listing, appended to this Section 2.24.

2.24.4 Results of Economic Analysis

The results of the Economic Analysis for the BIA Highway 6 are listed in Table 2.24-3.

Stochastic Analysis Results: The flood protection strategy that was analyzed for protecting BIA Highway 6 was five incremental road raises. This strategy is highlighted on the decision tree (Figure 2.24-2). The average annual net benefits for this strategy were greater than zero ($9,244,900). The BCR for this strategy was greater than one (62.71). These results indicate that this strategy was economically justified. The present worth annualized detour damages that would be prevented by this strategy were computed to be $9,392,500. The stochastic results are averages over 10,000 traces.

The large net benefits for this feature are primarily the result of the large detour damages when the road is temporarily closed. If it were assumed that ND Highway 20 would be available as the detour route, the net benefits for this feature would be significantly lower, potentially changing the economic feasibility of the flood protection strategy.

Results for Specific Scenarios: In the economic analysis, flood protection strategies were also analyzed for three specific climate futures. For BIA Highway 6, the identified strategy and the economic indices for each of the three climate futures are as follows:

- Wet Future – For the wet future, the annual net benefits were $12,532,900, and the BCR was 24.20, indicating that this strategy was economically justified. For this future, the present worth annualized detour damages that would be prevented were computed at $13,073,000.
- First Moderate Future – For the first moderate future, the annual net benefits were $10,714,900, and the BCR was 178.99, indicating that this strategy was economically justified. For this future, the present worth annualized detour damages that would be prevented were computed at $10,774,700.
- Second Moderate Future – For the second moderate future, the annual net benefits were $11,655,900, and the BCR was 45.30, indicating that this strategy was economically justified. For this future, the present worth annualized detour damages that would be prevented were computed at $11,914,200.

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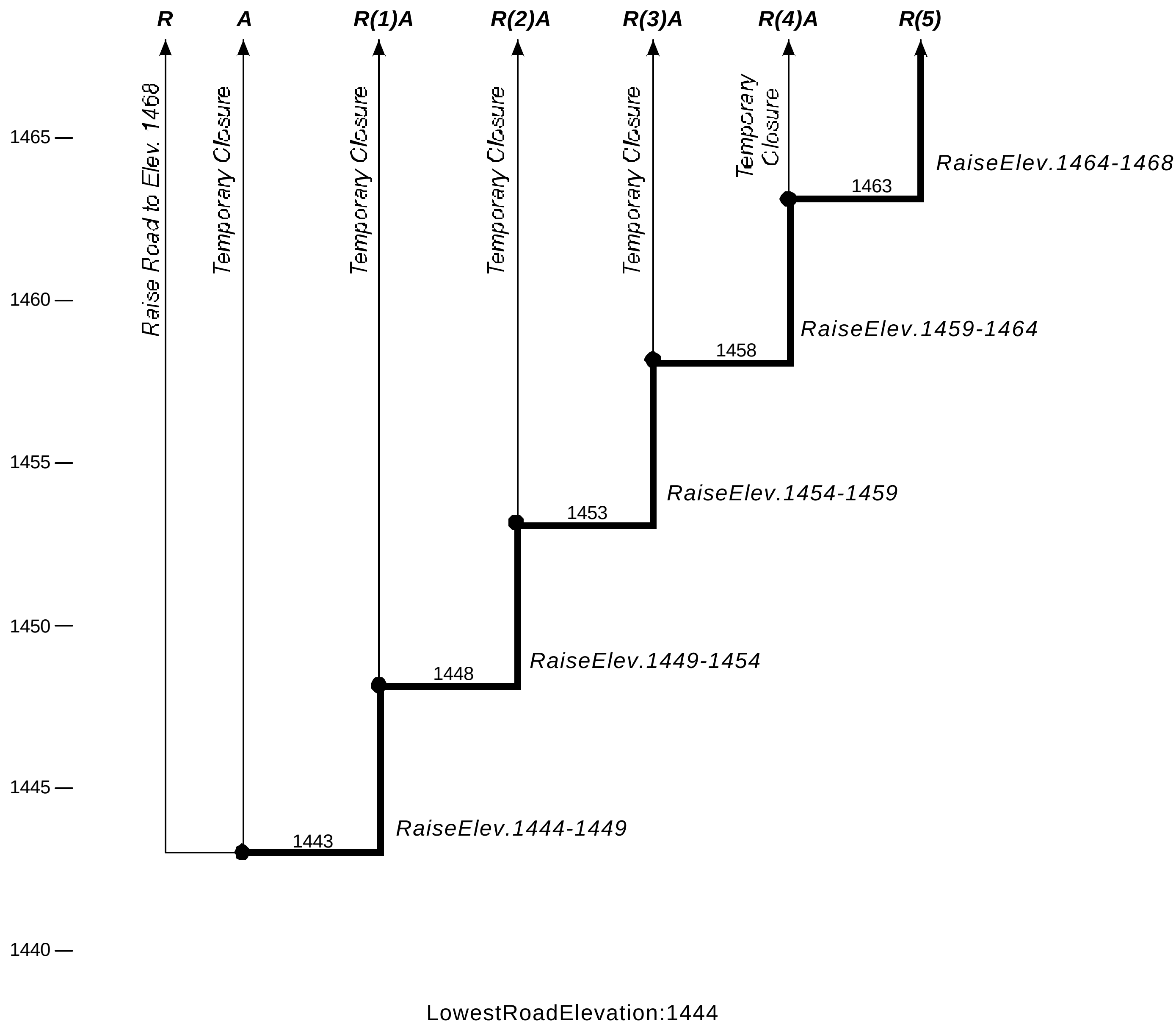

FloodProtectionStrategy

Decisionrequiredatthispoint

Triggerpointforaction,nodecisionneeded

R(1) Incrementalroad raise(number oftimes)

R Road raiseto1468

A Temporary closureofroad

Figure2.24-2

DECISION TREE
FEATURE 24:BIAHIGHWAY6
DevilsLakeInfrastructure ProtectionStudy

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Table 2.24-1

Flood Damages
Feature 24: BIA Highway 6
Devils Lake Infrastructure Protection Study

DAMAGES

Action Levels	Annual Detour Damages
	(THOUSANDS)
AL1 - AL5	$13,073

DAMAGE BREAKDOWN

	AL1 - AL5				
Damage	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Annual Detour Damages	BIA Highway 6				
	HR/YEAR	531,434	HR	$7.00	$3,720
	MILES/YEAR	29,228,873	MILE	$0.32	$9,353
	Total				$13,073

Restoration Damages																									
		Excavation				Fabric Liner				Aggregate Base Course				Fill				Bituminous Pavement				Bridge Repair			
Elevation	Total (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Value (THOUSANDS)	Quantity	Units	Unit Cost	Cost (THOUSANDS)
1443	$0																								
1444	$31	1,867	CY	$2.65	$5	3,321	SY	$1.33	$4	400	CY	$21.20	$8	2,767	CY	$4.77	$13	0	TON	$47.70	$0	0	EA	$530,000	$0
1445	$31	1,867	CY	$2.65	$5	3,321	SY	$1.33	$4	400	CY	$21.20	$8	2,767	CY	$4.77	$13	0	TON	$47.70	$0	0	EA	$530,000	$0
1446	$31	1,867	CY	$2.65	$5	3,321	SY	$1.33	$4	400	CY	$21.20	$8	2,767	CY	$4.77	$13	0	TON	$47.70	$0	0	EA	$530,000	$0
1447	$31	1,867	CY	$2.65	$5	3,321	SY	$1.33	$4	400	CY	$21.20	$8	2,767	CY	$4.77	$13	0	TON	$47.70	$0	0	EA	$530,000	$0
1448	$31	1,867	CY	$2.65	$5	3,321	SY	$1.33	$4	400	CY	$21.20	$8	2,767	CY	$4.77	$13	0	TON	$47.70	$0	0	EA	$530,000	$0
1449	$31	1,867	CY	$2.65	$5	3,321	SY	$1.33	$4	400	CY	$21.20	$8	2,767	CY	$4.77	$13	0	TON	$47.70	$0	0	EA	$530,000	$0
1450	$31	1,867	CY	$2.65	$5	3,321	SY	$1.33	$4	400	CY	$21.20	$8	2,767	CY	$4.77	$13	0	TON	$47.70	$0	0	EA	$530,000	$0
1451	$31	1,867	CY	$2.65	$5	3,321	SY	$1.33	$4	400	CY	$21.20	$8	2,767	CY	$4.77	$13	0	TON	$47.70	$0	0	EA	$530,000	$0
1452	$31	1,867	CY	$2.65	$5	3,321	SY	$1.33	$4	400	CY	$21.20	$8	2,767	CY	$4.77	$13	0	TON	$47.70	$0	0	EA	$530,000	$0
1453	$31	1,867	CY	$2.65	$5	3,321	SY	$1.33	$4	400	CY	$21.20	$8	2,767	CY	$4.77	$13	0	TON	$47.70	$0	0	EA	$530,000	$0
1454	$546	32,822	CY	$2.65	$87	58,391	SY	$1.33	$78	7,033	CY	$21.20	$149	48,658	CY	$4.77	$232	0	TON	$47.70	$0	0	EA	$530,000	$0
1455	$546	32,822	CY	$2.65	$87	58,391	SY	$1.33	$78	7,033	CY	$21.20	$149	48,658	CY	$4.77	$232	0	TON	$47.70	$0	0	EA	$530,000	$0
1456	$546	32,822	CY	$2.65	$87	58,391	SY	$1.33	$78	7,033	CY	$21.20	$149	48,658	CY	$4.77	$232	0	TON	$47.70	$0	0	EA	$530,000	$0
1457	$667	40,133	CY	$2.65	$106	71,397	SY	$1.33	$95	8,600	CY	$21.20	$182	59,497	CY	$4.77	$284	0	TON	$47.70	$0	0	EA	$530,000	$0
1458	$1,087	65,333	CY	$2.65	$173	116,228	SY	$1.33	$155	14,000	CY	$21.20	$297	96,855	CY	$4.77	$462	0	TON	$47.70	$0	0	EA	$530,000	$0
1459	$1,087	65,333	CY	$2.65	$173	116,228	SY	$1.33	$155	14,000	CY	$21.20	$297	96,855	CY	$4.77	$462	0	TON	$47.70	$0	0	EA	$530,000	$0
1460	$1,087	65,333	CY	$2.65	$173	116,228	SY	$1.33	$155	14,000	CY	$21.20	$297	96,855	CY	$4.77	$462	0	TON	$47.70	$0	0	EA	$530,000	$0
1461	$1,087	65,333	CY	$2.65	$173	116,228	SY	$1.33	$155	14,000	CY	$21.20	$297	96,855	CY	$4.77	$462	0	TON	$47.70	$0	0	EA	$530,000	$0
1462	$1,087	65,333	CY	$2.65	$173	116,228	SY	$1.33	$155	14,000	CY	$21.20	$297	96,855	CY	$4.77	$462	0	TON	$47.70	$0	0	EA	$530,000	$0
1463	$1,087	65,333	CY	$2.65	$173	116,228	SY	$1.33	$155	14,000	CY	$21.20	$297	96,855	CY	$4.77	$462	0	TON	$47.70	$0	0	EA	$530,000	$0

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.

Table 2.24-2

Flood Protection Costs
Feature 24: BIA Highway 6
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Action Level	Lake Elevation	R Maximum Raise at AL1	A Temporary Closure at AL1	R(1)A Raise at AL1; Temporary Closure at AL2	R(2)A Raise at AL1, AL2; Temporary Closure at AL3	R(3)A Raise at AL1, AL2, AL3; Temporary Closure at AL4	R(4)A Raise at AL1, AL2, AL3, AL4; Temporary Closure at AL5	R(5) Raise at AL1, AL2, AL3, AL4, AL5
	(MSL)				(THOUSANDS)			
AL1	1443	$19,773	$0	$214	$214	$214	$214	$214
AL2	1448	$0	$0	$0	$1,664	$1,664	$1,664	$1,664
AL3	1453	$0	$0	$0	$0	$5,065	$5,065	$5,065
AL4	1458	$0	$0	$0	$0	$0	$6,568	$6,568
AL5	1463	$0	$0	$0	$0	$0	$0	$6,262

COST BREAKDOWN

Strategy		R				
		R(1)A				
		R(2)A				
		R(3)A				
		R(4)A				
		R(5)				
		Lake Elevation 1443				
Incremental Raise		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
	Road Raise	BIA Highway 6				
		Fabric Liner	5,211	SY	$1.33	$7
		Aggregate Base	400	CY	$21.20	$8
		Fill	10,444	CY	$9.00	$94
		Riprap	3,487	TON	$30.00	$105
		Bituminous	0	TON	$47.70	$0
		Subtotal				$214
		Total				**$214**

Strategy		R(2)A				
		R(3)A				
		R(4)A				
		R(5)				
		Lake Elevation 1448				
Incremental Raise		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
	Road Raise	BIA Highway 6				
		Fabric Liner	52,827	SY	$1.33	$70
		Aggregate Base	6,633	CY	$21.20	$141
		Fill	43,633	CY	$9.00	$393
		Riprap	35,351	TON	$30.00	$1,061
		Bituminous	0	TON	$47.70	$0
		Subtotal				$1,664
		Total				**$1,664**

Strategy		R(3)A				
		R(4)A				
		R(5)				
		Lake Elevation 1453				
Incremental Raise		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
	Road Raise	BIA Highway 6				
		Fabric Liner	112,438	SY	$1.33	$150
		Aggregate Base	6,967	CY	$21.20	$148
		Fill	278,933	CY	$9.00	$2,510
		Riprap	75,243	TON	$30.00	$2,257
		Bituminous	0	TON	$47.70	$0
		Subtotal				$5,065
		Total				**$5,065**

Strategy		R(4)A				
		R(5)				
		Lake Elevation 1458				
Incremental Raise		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
	Road Raise	BIA Highway 6				
		Fabric Liner	95,845	SY	$1.33	$127
		Aggregate Base	0	CY	$21.20	$0
		Fill	501,778	CY	$9.00	$4,516
		Riprap	64,137	TON	$30.00	$1,924
		Bituminous	0	TON	$47.70	$0
		Subtotal				$6,568
		Total				**$6,568**

Strategy		R(5)				
		Lake Elevation 1463				
Incremental Raise		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
	Road Raise	BIA Highway 6				
		Fabric Liner	76,675	SY	$1.33	$102
		Aggregate Base	0	CY	$21.20	$0
		Fill	513,422	CY	$9.00	$4,621
		Riprap	51,310	TON	$30.00	$1,539
		Bituminous	0	TON	$47.70	$0
		Subtotal				$6,262
		Total				**$6,262**

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. The costs for the Maximum Raise at AL1 strategy (R) is equal to the sum of the costs for all incremental raises.

Table 2.24 - 3

Economic Analysis of Strategies for BIA 6 between Highway 1 and Fort Totten
(Feature 24)

Stochastic Analysis (ST)
Mean Value over 10,000 Traces (Annual)

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Relocation	Total	Restoration	Detour	Relocation Detour	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C = A + B	D	E	F	G = D + E + F	H = G(A) - G(S) *	I = H - C	J = H / C
A	Temporary Closure During Floods at First Action	$0	$0	$0	$2,200	$9,392,500	$0	$9,394,700	$0	$0	--
R	Road Raise to 1468	########	$0	$1,241,500	$0	$0	$0	$0	$9,394,700	$8,153,300	7.57
R(1)A	1 Road Raise: Then Temporary Closure During F	$13,400	$0	$13,400	$3,300	$4,038,200	$0	$4,041,500	$5,353,300	$5,339,800	399.50
R(2)A	2 Road Raises: Then Temporary Closure During	$86,300	$0	$86,300	$3,500	$878,000	$0	$881,500	$8,513,200	$8,427,000	98.65
R(3)A	3 Road Raises: Then Temporary Closure During	$128,900	$0	$128,900	$2,500	$235,500	$0	$238,000	$9,156,800	$9,027,900	71.04
R(4)A	4 Road Raises: Then Temporary Closure During	$148,300	$0	$148,300	$0	$6,900	$0	$6,900	$9,387,900	$9,239,600	63.30
R(5)	5 Incr. Road Raises	$149,800	$0	$149,800	$0	$0	$0	$0	$9,394,700	$9,244,900	62.71

Wet Future Scenario (WF)
(Annual)

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Relocation	Total	Restoration	Detour	Relocation Detour	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C = A + B	D	E	F	G = D + E + F	H = G(A) - G(S) *	I = H - C	J = H / C
A	Temporary Closure During Floods at First Action	$0	$0	$0	$0	#########	$0	$13,073,000	$0	$0	--
R	Road Raise to 1468	########	$0	$1,241,500	$0	$0	$0	$0	$13,073,000	$11,831,500	10.53
R(1)A	1 Road Raise: Then Temporary Closure During F	$13,400	$0	$13,400	$0	#########	$0	$12,252,200	$820,800	$807,300	61.25
R(2)A	2 Road Raises: Then Temporary Closure During	$111,700	$0	$111,700	$13,400	$8,348,300	$0	$8,361,700	$4,711,300	$4,599,700	42.18
R(3)A	3 Road Raises: Then Temporary Closure During	$331,100	$0	$331,100	$14,600	$4,193,600	$0	$4,208,200	$8,864,800	$8,533,700	26.77
R(4)A	4 Road Raises: Then Temporary Closure During	$540,100	$0	$540,100	$0	$0	$0	$0	$13,073,000	$12,532,900	24.20
R(5)	5 Incr. Road Raises	$540,100	$0	$540,100	$0	$0	$0	$0	$13,073,000	$12,532,900	24.20

Moderate Future 1 Scenario (M1)
(Annual)

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Relocation	Total	Restoration	Detour	Relocation Detour	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C = A + B	D	E	F	G = D + E + F	H = G(A) - G(S) *	I = H - C	J = H / C
A	Temporary Closure During Floods at First Action	$0	$0	$0	$500	#########	$0	$10,775,100	$0	$0	--
R	Road Raise to 1468	########	$0	$1,241,500	$0	$0	$0	$0	$10,775,100	$9,533,700	8.68
R(1)A	1 Road Raise: Then Temporary Closure During F	$13,400	$0	$13,400	$800	$1,037,900	$0	$1,038,700	$9,736,400	$9,723,000	726.60
R(2)A	2 Road Raises: Then Temporary Closure During	$60,200	$0	$60,200	$0	$0	$0	$0	$10,775,100	$10,714,900	178.99
R(3)A	3 Road Raises: Then Temporary Closure During	$60,200	$0	$60,200	$0	$0	$0	$0	$10,775,100	$10,714,900	178.99
R(4)A	4 Road Raises: Then Temporary Closure During	$60,200	$0	$60,200	$0	$0	$0	$0	$10,775,100	$10,714,900	178.99
R(5)	5 Incr. Road Raises	$60,200	$0	$60,200	$0	$0	$0	$0	$10,775,100	$10,714,900	178.99

Moderate Future 2 Scenario (M2)
(Annual)

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Relocation	Total	Restoration	Detour	Relocation Detour	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C = A + B	D	E	F	G = D + E + F	H = G(A) - G(S) *	I = H - C	J = H / C
A	Temporary Closure During Floods at First Action	$0	$0	$0	$4,700	#########	$0	$11,919,000	$0	$0	--
R	Road Raise to 1468	########	$0	$1,241,500	$0	$0	$0	$0	$11,919,000	$10,677,500	9.60
R(1)A	1 Road Raise: Then Temporary Closure During F	$13,400	$0	$13,400	$9,500	$8,630,900	$0	$8,640,400	$3,278,600	$3,265,100	244.67
R(2)A	2 Road Raises: Then Temporary Closure During	$111,700	$0	$111,700	$12,000	$2,021,300	$0	$2,033,300	$9,885,700	$9,774,000	88.50
R(3)A	3 Road Raises: Then Temporary Closure During	$263,100	$0	$263,100	$0	$0	$0	$0	$11,919,000	$11,655,900	45.30
R(4)A	4 Road Raises: Then Temporary Closure During	$263,100	$0	$263,100	$0	$0	$0	$0	$11,919,000	$11,655,900	45.30
R(5)	5 Incr. Road Raises	$263,100	$0	$263,100	$0	$0	$0	$0	$11,919,000	$11,655,900	45.30

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.375% and rounded to the nearest $100.
* Total benefits are calculated as the total damages incurred for "temporary closure strategy" minus the total damages for the strategy implemented (G(S)).
The "No Protection" strategy for roads has been defined as temporary closure during floods at the first action level with restoration when the lake recedes.

Attachment to 2.24:
BIA Highway 6 Economic Analysis Assumptions

No feature-specific assumptions were made for Feature 24.

A. General Assumptions

1. Decisions were assumed to occur when the lake level is within (or predicted by the National Weather Service to be within) 1 foot of the lowest road elevation. This assumption is consistent with current practices in the area as dictated by funding agencies. In the past, funding for road raises has not been available until the National Weather Service predicts on February 15th that the road will go under water during that year.

2. If the road includes a bridge having a low chord elevation below the lowest road elevation, it was assumed that no decision would occur until the lake level was within 1 foot of the lowest road elevation. This assumption follows current practices in the area.

B. Road Raises

1. Road raise costs were calculated in the manner presented in a previous study (*Devils Lake Flood Control: Economics Database Update: Transportation Report*, Barr Engineering Company, January 1998). Unit costs for construction materials were updated for inflation by multiplying them by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001. Additionally the cost of riprap and fill were increased from $20 to $30 and $4.50 to $9.00, respectively. Based on conversations with the NDDOT, railroad companies, and the Corps of Engineers the new costs for riprap and fill are more representative of the costs in the area.

2. The last road raise was assumed to be to elevation 1468. At this elevation, roads would be 5 feet above the assumed maximum lake level (elevation 1463).

3. The final incremental road raise (to elevation 1468) was assumed to be no more than 8 feet and no less than 4 feet.

4. Bureau of Indian Affairs (BIA) roads were assumed to be raised in 5-foot increments (*Devils Lake Flood Control: Economics Database Update: Transportation Report,* Barr Engineering Company, January 1998).

C. Temporary Road Closure During Floods

1. It was assumed that if a road was temporarily closed, it would be restored after the lake level has receded 1 foot below the top of road. All of the road features in this study are highly traveled. It is very likely that people would want to use these roads again if the lake level receded after flooding,

assuming that communities, businesses, farmsteads, and residents continue to generate the same level of traffic as at present.

2. Restoration damages were calculated in the manner presented in *Devils Lake Flood Control: Economics Database Update: Transportation Report*, Barr Engineering Company, January 1998. Unit costs for construction materials were updated for inflation by multiplying them by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001.

3. Detour damages were included for every year that a road is temporarily closed, as well as for the first year that the lake has receded. It was assumed that during the first year after the lake has receded, the road would be under restoration. During this first year, there would be both a detour damage and restoration damage. After this first year, there would be no further detour or restoration damages unless the lake rises to within 1 foot of the road again.

4. Restoration of a road would only occur after the lake has receded to 1 foot below the lowest elevation in that road. This was based on the assumption that restoration would only occur when there is no water on any part of the road and there would be only minor potential for wave action damage on the road.

5. Detour damages were calculated using a cost of $7 per hour of additional travel time, 1.5 people per vehicle, and $0.32 per mile for additional travel distance (Corps of Engineers, March, 2001). Additional time and miles traveled were taken from the results of the QRS II model used in *Devils Lake Flood Control: Economics Database Update: Transportation Report*, Barr Engineering Company, January 1998. The QRS II model determines the overall effect of a closed road on an entire network of traffic, incorporating the fact that traffic consists of trips having different origins and destinations.

6. There is more commitment on the part of the North Dakota Department of Transportation (NDDOT) to the Highway 57 causeway than to the Highway 20 causeway through The Narrows. Therefore, Highway 57 was assumed to be the detour route for the Highway 20 causeway. If the Highway 57 causeway was temporarily closed during flooding, it was assumed that the Highway 20 causeway would also be temporarily closed.

7. The detour route for Highway 57 is around the lake to the west via Highway 281 and Highway 19. Woods-Rutten Road was considered as a detour route for Highway 57, but it was not retained as a viable alternative, because it would have to be significantly raised and improved to carry the traffic of Highway 57.

8. Detour paths were determined assuming that all other featured roads would be open (with three exceptions: the Highway 57 detour assumes that Highway 20 across The Narrows is closed and both

the BIA 1 and the BIA 6 detours assume that Highway 20 from Highway 57 to Tokio is closed). No effort was made to link detour routes with lake level. However, if a featured road was presented as a detour route, an "interdependency" was noted.

9. The analysis of Features 23 (BIA 1 between Highway 57 and BIA 6) and Feature 24 (BIA 6 between Highway 20 and Fort Totten) assumed that Feature 22 (Highway 20 between Highway 57 and Tokio) is temporarily closed during high lake levels. BIA 1 and BIA 6 are part of the north-south detour for Highway 20 and the preliminary analysis indicated that Feature 22 would likely be temporarily closed during high lake levels.

10. Two features can have mutually interdependent detour routes if they are the most reasonable detours. In these cases, it was assumed that either the analyzed feature or the other feature would be raised or rerouted. In these cases, the interdependency was noted.

D. Road Reroutes

1. No logical reroute was located for this feature.

2.25 Summary of Economic Analysis Investigation for Feature 25: Roads Acting as Dams

2.25.0 Flood Protection Strategy

The flood protection strategy that was analyzed for the Roads Acting as Dams area was incremental levee raises.

2.25.1 General Information

This feature was not originally included in the Economic Analysis of Devils Lake Alternatives as a feature. However it was analyzed as the Expanded Infrastructure Measures alternative ST-2b and WF-2b, which are summarized in this section. No assumptions attachment is included in this write-up. Assumptions for the Economic Analysis can be found in the *Roadways Serving as Water Barriers Report*, Devils Lake Surface Transportation Task Force, May 2000.

Feature Type: Combination

Location: The Roads Acting as Dams feature includes two separate sections: (1) along ND Highway 20, located near the Acorn Ridge area in Creel Township, Ramsey County; and (2) the Mission Township peninsula on the south side of the lake near St. Michael (located in Mission Township, Benson County). The accompanying Figure 2.25-1 shows the feature's location and approximate extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: There are several locations around Devils Lake in which roads are currently holding back water, providing barriers to the rising and expanding waters of Devils Lake. The problem originated when culverts were plugged in 1995 to protect existing features. The difference in water levels on each side of the road is now as much as 12 feet. The extent of the roads currently holding back water is approximately 10.8 miles. Since these roads are acting as dams, but were not designed or constructed to function as dams, there is a potential safety hazard to road users and to the people living behind and using the areas being protected by these barriers. Portions of ND Highway 57, ND Highway 20, BIA Highway 1, BIA Highway 4, and BIA Highway 5 are currently holding back water and providing barriers for the rising and expanding Devils Lake. There are also three sections of temporary levees that have been constructed by the Corps to protect the area in Mission Township.

This alternative examined the economic feasibility of taking additional measures to provide a safe level of flood protection behind these barriers. The alternative assumed that several perimeter dams would be constructed between high ground (to minimize the number of roads that need to be raised) and that dams would be constructed adjacent to and inside the protection of any remaining exterior roads (including: Highway 20 near the Acorn Ridge development, BIA 4, and BIA 5). These dams would then become the flood protection for the interior areas, allowing the roads to be relocated or temporarily closed.

Significance: The areas behind these roads have been protected because of their value to the local community. The roads that are being used as dams and the interior roads are significant for transportation reasons (the major roads were evaluated separately as other features). The Roads Acting as Dams are currently protecting the following features from flooding: Feature 5, St. Michael, Feature 8.1; Rural Areas, Feature 22; ND Highway 20 (ND Highway 57 to Tokio); Feature 24, BIA Highway 6.

Damages: The loss of these "dams" from either failure or flooding up to the maximum lake level would result in the following damages:

- Loss of the portions of ND Highway 57 (Feature 14), ND Highway 20 (Features 21 and 22), BIA Highway 1 (Feature 23), BIA Highway 4, and BIA Highway 5 that are currently acting as dams
- Loss of portions of ND Highway 22 (Feature 22), BIA Highway 1 (Feature 23), BIA Highway 6 (Feature 24), BIA Highway 9, BIA Highway 2, and Military Road due to flooding
- Loss of commercial and residential structures in St. Michael (Feature 5)
- Loss of the St. Michael sewer lagoon system
- Loss of approximately 71 rural residential structures (Feature 8.1)
- Loss of land area that is currently protected

Owner/Sponsor: The North Dakota Department of Transportation (ND DOT) is responsible for maintaining ND Highways 57 and 20. The Bureau of Indian Affairs is responsible for managing and maintaining BIA Highway 1, BIA Highway 4, BIA Highway 5, and BIA Highway 9. The Spirit Lake Nation is responsible for managing and maintaining St. Michael.

Lead Federal Agency: Several agencies could be responsible for portions of flood protection that may take place for the Roads Acting as Dams feature. The Corps would take the lead for any levee flood protection that may take place. Federal Emergency Management Agency (FEMA) would coordinate relocation of structures. The Federal Highway Administration would take the lead in installing pipe(s) to equalize water on both sides of the roadway, and to raise the elevation of state roads. The Bureau of Indian Affairs would take the lead on raising the BIA roads and individual counties would be responsible for flood protection of county roads.

2.25.2 Feature Protection

History of Flood Protection: In the past, flood protection for the Roads Acting as Dams has consisted of raising the roads in 5-foot increments when the water level reaches one foot below the road elevation.

In addition, emergency levees were constructed north and northeast of the east-west portion of ND Highway 20. The western-most of the three levees, constructed along a township road in Section 35 (T153N64W), was raised to 1447.6 in 1998. The other two levee sections, located in Section 35 (T153N64W) and Section 31 (T153N63W), were also raised in 1998 to 1449. These levees protect land to the south and the 2,000-foot section of ND Highway 20 immediately west of the road's intersection with BIA Highway 9 that has a surface elevation at about 1445.

General Protection Strategy: Several approaches were taken in the analysis that was completed by the Corps and the Devils Lake Surface Transportation Task Force, including:

- Construction of several perimeter dams between areas of high ground, with the remaining exterior roads being converted to dams
- Construction of several perimeter dams between areas of high ground, with construction of parallel dams along exterior roads

The Economic Analysis evaluated the second approach for protecting the Roads Acting as Dams: construction of perimeter dams.

Protection Strategy by Lake Level: The Economic Analysis considered one protection strategy, with flood protection decisions being made at various lake levels as Devils Lake continued to rise. Figure 2.25-2 shows the decision tree for Roads Acting as Dams. As shown on Figure 2.25-2, the stepwise approach to flood protection for Roads Acting as Dams that was analyzed consisted of the following:

1. At lake elevation 1447, a decision would be made whether to construct the perimeter levees with a top at 1455 or allow the water levels to equalize and conduct the flood protection strategies for each feature as analyzed.
2. At lake elevation 1450, if the perimeter levees were constructed at the first action level, the perimeter dams would be raised to a top of 1465.

Interdependencies: The protection of Roads Acting as Dams is related to the protection of:

- Feature 5: St. Michael – St. Michael is currently protected by Roads Acting as Dams, and decisions regarding these features must be considered jointly.

- Feature 8.1: Rural Areas – There are portions of rural areas that are being protected by Roads Acting as Dams, and future flood protection decisions should consider the Rural Areas.

- Feature 14: ND Highway 57 (between ND Highway 20 and BIA Highway 1) – A portion of ND Highway 57 is acting as a dam, and decisions regarding this road will affect other features in the interior areas that are being protected.

- Features 21 and 22: ND Highway 20 – Two sections of ND Highway 20 are acting as dams, and decisions regarding these road segments will affect other features in the interior areas that are being protected. Other sections of ND Highway 20 are being protected by Roads Acting as Dams. Therefore, decisions regarding these features must be considered at the same time.

- Feature 23: BIA Highway 1 – A segment of BIA Highway 1 is acting as a dam, and decisions regarding this road will affect other features in the interior areas that are being protected. As the lake rises, other portions of BIA Highway 1 would be protected by Roads Acting as Dams. Therefore, decisions regarding these features must be considered at the same time.

- Feature 24: BIA Highway 6 – BIA Highway 6 is currently protected by Roads Acting as Dams, and decisions regarding these features must be considered jointly.

- Additional roadways including Military Road and BIA Highways 2, 4, and 5 – These roadways were not considered as individual features, however they would be impacted by future flood protection decisions for the Roads Acting as Dams.

2.25.3 Feature Economics

Damages: For Roads Acting as Dams, the damages resulting from flooding were estimated up to the maximum lake level (1463). The damage computations for Roads Acting as Dams are the prevention of protection measures at the affected features, and are summarized in the accompanying Table 2.25-1 as the annual benefits from each respective feature. These damages prevented included feature costs as follows:

- Feature 5 (St. Michael) – Relocation costs were eliminated.

- Feature 24 (BIA Highway 6) – Road raise costs were eliminated.

- Feature 22 (Highway 20 (ND Highway 57 and Tokio) – Road raise costs were eliminated for the segment between BIA Highway 5 and Tokio. The revised Feature 22 costs would reflect only those costs for raising the segment between Highway 57 and BIA Highway 5 (at the perimeter dam). The revised raises for Feature 22 were computed to be $4,574,000 at elevation 1454 and $6,481,000 at 1459.

- Feature 8.1 (Devils Lake Rural Areas) – Damages to structures were eliminated. Homes that would be within the protected area include 54 homes on the reservation and 21 homes in the Acorn Ridge area (near Camp Grafton). There were also an additional 84 homes where access would be protected by this feature. The total reduction in damages to homes that are protected was computed to be $7,800,000. The total reduction in relocation costs was computed at $7,956,000. Land that is protected by this alternative (valued at $178,600) was also removed from the potential damages.

Costs: The construction costs for implementation of the Expanded Infrastructure Measures alternative were obtained from the *Roadways Serving as Water Barriers Report*, Devils Lake Surface Transportation Task Force, May 2000. These costs are summarized in Table 2.25-2.

The project costs include:

- Costs to raise levees on the landward side of US Highway 20 near Acorn Ridge, BIA Highway 4, and BIA Highway 5. These costs occur incrementally as necessary due to the rising lake levels.
- Costs for levee (perimeter dam) construction to connect high ground. These costs also occur incrementally as necessary due to the rising lake levels.
- Operation and maintenance costs for the new levees. Operation and maintenance costs were assumed to be 1% of the total project costs. These costs were assumed to include operation of temporary pumping stations to remove interior drainage and maintenance of the levees.

2.25.4 Results of Economic Analysis

The results of the Economic Analysis for the Roads Acting as Dams are listed in Table 2.25-3.

Stochastic Analysis Results: The stochastic analysis indicated that the annual net benefits for Expanded Infrastructure Measures (Roads Acting as Dams) were less than zero (-$6,141) and were therefore not economically justified. This protection strategy is highlighted on the decision tree (Figure 2.25-2). The BCR for this strategy was less than one (0.99). The stochastic results are averages over 10,000 traces.

Results for Specific Scenarios: In the economic analysis, flood protection strategies were also analyzed for the Wet Future climate future. For the wet future, the protection strategy had an annual net benefits that were less than zero (-$2,803,900) and a BCR of 0.31. Therefore, this protection strategy was not economically justified under the wet future.

Figure 2.25-1
LOCATION MAP
FEATURE 25: ROADS
ACTING AS DAMS
Devils Lake Infrastructure
Protection Study

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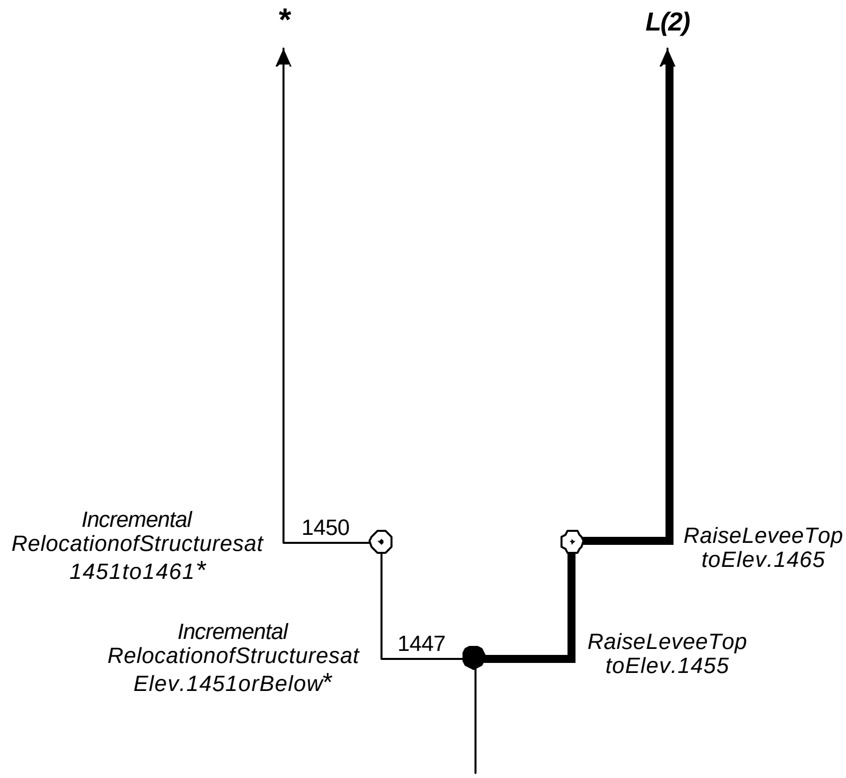

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	FloodProtectionStrategy
	Decisionrequiredatthispoint
	Triggerpointforaction,nodecisionneeded
L(1)	Incrementalleveeraise(numberoftimes)
S(1)	Structurerelocation(numberoftimes)
*	Inadditiontostructurerelocations,NDHighway20, BIAHighway6andSt.Michaelwouldrequireflood protection.Theseanalyses wereincludedasother features.

Figure2.25-2

DECISION TREE
FEATURE25:ROADSACTINGASDAMS
DevilsLakeInfrastructure ProtectionStudy

Table 2.25-1

Flood Damages
Feature 25: Roads Acting as Dams
Devils Lake Infrastructure Protection Study

DAMAGES

	Impacted Feature	Stochastic Analysis		
		Annual Costs Avoided (averaged over 10,000 traces) (Thousands)	**Annual Damages Reduced** (averaged over 10,000 traces) (Thousands)	**TOTAL** (averaged over 10,000 traces) (Thousands)
5	St. Michael	$20	$0	$20
8.1	Devils Lake Rural Areas	$311	$5	$316
22	ND Highway 20 (ND Highway 57 to Tokio	-$47	$697	$650
23	BIA Highway 1	$18	-$11	$7
24	BIA Highway 6	$150	$0	$150
			TOTAL	**$1,143**

	Impacted Feature	Wet Future Scenario Analysis		
		Annual Costs Avoided (averaged over 10,000 traces)	**Annual Damages Reduced** (averaged over 10,000 traces)	**TOTAL** (averaged over 10,000 traces)
5	St. Michael	$76	$0	$76
8.1	Devils Lake Rural Areas	$415	$9	$423
22	ND Highway 20 (ND Highway 57 to Tokio	-$369	$576	$208
23	BIA Highway 1	$230	-$218	$12
24	BIA Highway 6	$540	$0	$540
			TOTAL	**$1,259**

Table 2.25-2

Flood Protection Costs
Feature 25: Roads Acting as Dams
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Action Level	Lake Elevation	L(2) Incremental Install Perimeter Dams, Incremental Raise Hwy 20 (Acorn Ridge) at AL 1, raise perimeter dams and parallel dam at AL 2
	(MSL)	(THOUSANDS)
AL1	1447	$31,771
AL2	1450	$63,602

COST BREAKDOWN - Perimeter Dams

Strategy		L(2) Lake Elevation 1447 Dam Segment	Lake Elevation 1447 Estimated Cost	Lake Elevation 1450 Dam Segment	Lake Elevation 1450 Estimated Cost
Perimeter Dam			(THOUSANDS)		(THOUSANDS)
	Dam Construction	A & L	$13,303	A & L	$22,822
		B	$194	B	$2,386
		C	$479	C	$3,027
		D	$254	D	$1,961
		E	$227	E	$392
		F	$116	F	$167
		G	$6,270	G	$10,717
		H	$2,580	H	$4,315
		I	$2,539	I	$5,546
		J	$1,357	J	$3,543
		K	$4,452	K	$8,726
		TOTAL	**$31,771**	**TOTAL**	**$63,602**

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. Costs from Alternatives Analysis, Alternative 3, completed by Paul Madison, COE St. Paul District, March 2000.

Table 2.25 - 3

Economic Analysis of Strategies for Roads Acting as Dams

(Feature 25)

Strategy		Stochastic Analysis (ST) Mean Value over 10,000 Traces (Annual)								
		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$1,143,200	$1,143,200	$0	$0	--
L(2)	2 Levee Raises	$1,013,290	$136,052	$0	$1,149,341	$0	$0	$1,143,200	-$6,100	0.99

Strategy		Wet Future Scenario (WF) (Annual)								
		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$1,259,100	$1,259,100	$0	$0	--
L(2)	2 Levee Raises	$3,660,051	$402,963	$0	$4,063,014	$0	$0	$1,259,100	-$2,803,900	0.31

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.375% and rounded to the nearest $100.
The Moderate Future Scenarios were not analyzed for this feature in the Economic Analysis of Devils Lake Alternatives study.
* Total benefits are calculated as the totall damages incurred for the "No Protection stragegy" minus the totall damages for the strategy implemented (F(S)).